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THE INFLUENCE OF CERTAIN HORMONE-LIKE SUBSTANCES ON THE ROOTING OF HARDWOOD BLUEBERRY CUTTINGS

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During recent years considerable interest has been aroused about the possibilities of using plant hormones or synthetic materials of the same nature to stimulate root growth on cuttings of various trees and shrubs, especially those not easily propagated.

For many years the highbush blueberry was classed among those plants difficult to propagate. However, recently methods have been developed that have resulted in high percentages of rooted cuttings although the cuttings develop roots slowly, requiring about three months to become well rooted. It was believed that one of the hormone-like plant growth substances might increase the speed of rooting which would be advantageous as well as possibly increasing the total percentage of rooting.

In the spring of 1937 a propagating frame was filled with a fine grade of German peat moss and planted with 160 cuttings each of the Rubel, Pioneer, Adams, and Cabot blueberry varieties. One-half of the cuttings were treated with a 40-unit solution of Hormodin "A" for 24 hours. The recommendations for the use of this material on blueberry cuttings did not give the suggested treatment for hardwood cuttings so the standard recommendation was used. This experiment did not include greenwood, leafy cuttings as hardwood cuttings have many practical advantages and are much preferred by commercial blueberry nurserymen. The solution apparently was not too strong as no evidence of injury could be observed in the cuttings. A duplicate planting

Table 1. Influence of Hormodin "A" on the length of time required to root blueberry cuttings, 1937.

Cuttings planted April 20. Ten of each variety examined on each date.

	May 20	June 4	June 18	July 1
TREATED:				
Rubel	0	0	0	4 (starting)
Pioneer	0	0	3 (starting)	8
Adams	0	0	4	8
Cabot	0	0	1	10
UNTREATED:				
Rubel	0	0	0	2
Pioneer	0	0	0	1
Adams	0	0	0	1
Cabot	0	0	4 (starting)	8

NOTE: All root systems were small on July 1.

Table 2. Influence of Hormodin "A" on the percentage of rooting of blueberry cuttings, 1937.

(40 cuttings in lot)

	Number Rooted	Per cent Rooted
TREATED:		
Rubel	39	97.5
Pioneer	28	70.0
Adams	39	97.5
Cabot	33	82.5
UNTREATED:		
Rubel	40	100.0
Pioneer	39	97.5
Adams	40	100.0
Cabot	39	97.5

was made in the other half of the frame with untreated cuttings; therefore, the cuttings in each lot were growing under the same conditions of light, moisture, and temperature.

The cuttings were planted April 20, and 10 of each variety in each

Table 3. The influence of Hormodin "A" and Auxilin on the speed of rooting of blueberry cuttings, 1938.

(20 cuttings in each lot)

Variety and Treatment	Dates of Examination and Number of Cuttings Showing Roots		
	June 1	June 21	July 12
Rubel.....Auxilin 2	0	2	5
Adams.....Auxilin 2	0	1	4
Cabot.....Auxilin 2	0	5	5
Pioneer.....Auxilin 2	0	3	4
Rubel.....Check	0	2	5
Rubel.....Auxilin 3	0	3	4
Adams.....Auxilin 3	0	3	4
Cabot.....Auxilin 3	0	4	5
Pioneer.....Auxilin 3	0	4	3
Adams.....Check	0	1	4
Rubel.....Auxilin 4	0	0	4
Adams.....Auxilin 4	0	4	4
Cabot.....Auxilin 4	2	5	5
Pioneer.....Auxilin 4	0	5	4
Rubel.....Hormodin "A" 20	0	1	5
Adams.....Hormodin "A" 20	0	3	4
Cabot.....Hormodin "A" 20	0	5	5
Pioneer.....Hormodin "A" 20	1	4	5
Cabot.....Check	1	5	5
Rubel.....Hormodin "A" 40	0	3	5
Adams.....Hormodin "A" 40	0	1	5
Cabot.....Hormodin "A" 40	1	5	5
Pioneer.....Hormodin "A" 40	0	3	5
Pioneer.....Check	2	3	4
Rubel.....Hormodin "A" 80	0	1	4
Adams.....Hormodin "A" 80	0	4	5
Cabot.....Hormodin "A" 80	1	3	4
Pioneer.....Hormodin "A" 80	1	4	4

NOTES:

Five cuttings lifted in each lot on each date.
June 1 —Roots just starting.
June 5 —Root systems all very small.
June 21—Root systems on Cabot larger than others. Rubel root systems smallest.

half of the frame were examined at two-week intervals beginning May 20. The results of these examinations are shown in Table 1. No rooting started until June 18 and on July 1 some root formation had started in all lots although the root systems were all small. A higher percentage of cuttings were beginning to root by July 1 among those treated with Hormodin "A". However, rooting had not been speeded sufficiently to be of any commercial significance.

At the end of the season, the 40 remaining cuttings of each variety in the treated and untreated lots were examined; the results are shown in Table 2. Better results were obtained with all varieties that were untreated, the difference being significant with Pioneer and Cabot. No difference in size of plants could be observed.

Further Investigations

In 1938 the experiment was continued and broadened to include other concentrations of Hormodin "A" and also to include three concentrations of Auxilin. Twenty,- forty,- and eighty-unit solutions of Hormodin "A" were used, and suggested strength of treatment numbers 2, 3, and 4 of Auxilin. The basal ends of all lots of cuttings were soaked in these solutions for 16 hours, thoroughly rinsed, and planted. The cuttings for that part of the experiment concerning the speed of rooting, were all planted in one propagating frame and those used to determine the total percentage of rooting were all planted in another frame, thus making certain that comparative lots were grown under the same conditions.

Table 4. The influence of Hormodin "A" and Auxilin on the total number of hardwood blueberry cuttings rooting, 1938.

(20 cuttings in each lot)

Variety and Treatment	Total Number Cuttings Rooted
Rubel.....Auxilin 2	18
Adams.....Auxilin 2	12
Cabot.....Auxilin 2	19
Pioneer.....Auxilin 2	10
Rubel.....Check	19
Rubel.....Auxilin 3	20
Adams.....Auxilin 3	12
Cabot.....Auxilin 3	20
Pioneer.....Auxilin 3	18
Adams.....Check	12
Rubel.....Auxilin 4	20
Adams.....Auxilin 4	16
Cabot.....Auxilin 4	18
Pioneer.....Auxilin 4	19
Rubel.....Hormodin "A" 20	20
Adams.....Hormodin "A" 20	14
Cabot.....Hormodin "A" 20	18
Pioneer.....Hormodin "A" 20	14
Cabot.....Check	15
Rubel.....Hormodin "A" 40	19
Adams.....Hormodin "A" 40	14
Cabot.....Hormodin "A" 40	19
Pioneer.....Hormodin "A" 40	18
Pioneer.....Check	19
Rubel.....Hormodin "A" 80	20
Adams.....Hormodin "A" 80	12
Cabot.....Hormodin "A" 80	17
Pioneer.....Hormodin "A" 80	15

Table 3 gives the results obtained in that part of the experiment devised to determine the influence of various strengths of Hormodin "A" and Auxilin on the speed of rooting. The use of these materials apparently did not cause the cuttings to form roots in less time. If there were any differences in certain instances, they were so insignificant as to be commercially unimportant.

The data regarding the influence of the materials on the total percentage of rooting are shown in Table 4. In 1937 Pioneer and Cabot cuttings treated with Hormodin "A" did not root as well as those untreated. In 1938 similar results occurred with reference to Pioneer, but certain lots of the treated cuttings of Adams and Cabot reacted better than did the untreated. It seemed to make little difference with Rubel whether the cuttings were treated.

Reviewing the two years' work, it is apparent that the use of Hormodin "A" and Auxilin was of little value in producing speedier root formation in blueberry cuttings. The data on total percentage of rooting are slightly more inconclusive, although there is little if any evidence to prove the value of the added expense and trouble of using the materials in blueberry propagation.

While the results of this experiment indicate that those materials, which have been useful in stimulating root formation on cuttings of some other plants, were not useful in that respect with blueberries, it is quite possible that in the future similar, or perhaps entirely different, substances may be found which will prove to be of value with certain blueberry varieties especially difficult to propagate.

THE INFLUENCE OF DIFFERENT LEVELS OF FAT IN THE RATION UPON MILK AND FAT SECRETION

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The relation of the quality and quantity of fat in the ration of dairy cattle to milk and fat production has received the attention of many investigators. Literature on this problem has been reviewed by Allen (1), Maynard and McCay (2), M'Candlish and Struthers (3), Anderson and Williams (4) and Garner and Sanders (5). Allen (1) and Garner and Sanders (5) showed that the addition of various fats resulted in an increased percentage of fat in the milk. Maynard and McCay (2) reported that a certain amount of food fat was necessary for optimum milk secretion. This article gives the results of an experiment designed to study the effect of different fat levels in the ration on the butterfat test and on milk production.

Experimental

Eight milking cows were divided into two groups (A and B) of four animals each and used in a double reversal experiment. The breed, age, calving date, and basal rations are shown in Table 1. It was neces-

Table 1. History of cows and basal rations used.*

No. Cow	Age	Weight**	Breed	Days** Since Last Calving	Basal Ration		
					Alfalfa	Beet Pulp	Molasses
	Years	Pounds			Pounds	Pounds	Pounds
Group A							
171	9	1,407	Holstein	182	22	15	3
246	6	1,260	Brown Swiss	139	22	15	3
7	9	1,110	Guernsey	85	20	13	3
66	8	970	Jersey	119	20	11	3
Group B							
218	3	1,315	Holstein	138	22	14	3
242	9	1,440	Brown Swiss	79	22	13	3
99	4	1,059	Jersey	47	20	13	3
101	3	968	Jersey	97	20	11	3

*Bonemeal fed to all animals.
**At beginning of experiment.

sary to use Jersey cow 99 in Group B to pair with Guernsey cow 7 in Group A. All the cows were in a good condition of flesh at the beginning of the experiment.

It was planned to keep the alfalfa, molasses and solvent-extracted soybean oil meal constant and make sugar beet pulp the variable.

The digestible protein, total digestible nutrients and ether extract of the feeds used in this investigation are shown in Table 2.

Four-day composite samples of milk were tested for butterfat. All the cows were fed the same ration during a four-day preliminary period. Group A received the basal ration low in fat supplemented with soybean oil during the period I. Group B received the basal ration low in fat during the first period. The groups were reversed at the end of each 24-day period.

During the periods when soybean oil was fed, it replaced an isodynamic amount of beet pulp. Enough soybean oil was added to the ration of each cow so that the total ether extract of the ration was equal to

Table 2. The digestible protein, total digestible nutrients, ether extract content of feeds used.*

	Digestible** Crude Protein	Total Digestible** Nutrients	Ether Extract
Alfalfa hay	10.72	50.7	1.77
Beet pulp	4.50	68.7	0.40
Molasses (beet)	7.38	59.6	—
Soybean oil meal (solvent)	39.1	78.0	0.70
Corn	9.70	81.5	3.30
Barley	12.39	74.50	1.00

*Chemical analyses of feeds by Section of Experiment Station chemistry.
**Used coefficients of digestibility in Feeds and Feeding, 20th ed., by Morrison.

Table 3. Effect of supplementing the basal ration fed to the cows in Group A with soybean oil.

4-day Periods	Average Daily Milk	Average Daily Butterfat	Fat	Average Daily 4% F.C.M.
	Pounds	Pounds	Per Cent	Pounds
Jan. 10-13	32.5	1.42	4.3	34.0
Period I—High Fat Ration				
Jan. 14-17	33.65	1.45	4.3	34.99
Jan. 18-21	30.20	1.29	4.3	33.46
Jan. 22-25	31.15	1.30	4.2	31.96
Jan. 26-29	31.01	1.27	4.1	31.38
Jan. 30-Feb. 2	31.19	1.29	4.1	31.83
Feb. 3-6	31.29	1.34	4.3	32.58
Period II—Low Fat Ration				
Feb. 7-10	30.78	1.09	3.5	28.62
Feb. 11-14	29.35	1.09	3.7	28.09
Feb. 15-18	27.20	1.11	4.1	27.49
Feb. 19-22	25.94	1.07	4.1	26.46
Feb. 23-26	24.67	1.04	4.2	25.51
Feb. 27-Mar. 1	24.53	1.00	4.1	25.22
Period III—High Fat Ration				
Mar. 2- 5	25.52	1.20	4.7	28.21
Mar. 6- 9	26.91	1.15	4.3	28.09
Mar. 10-13	28.36	1.20	4.2	29.38
Mar. 14-17	27.38	1.15	4.2	28.20
Mar. 18-21	27.76	1.08	3.9	27.30
Mar. 22-25	27.46	1.09	4.0	27.41

Table 4. Effect of supplementing the basal ration fed to the cows in Group B with soybean oil.

4-day Periods	Average Daily Milk	Average Daily Butterfat	Fat	Average Daily 4% F.C.M.
	Pounds	Pounds	Per Cent	Pounds
Jan. 10-13	33.24	1.41	4.2	34.48
Period I—Low Fat Ration				
Jan. 14-17	32.10	1.35	4.2	33.09
Jan. 18-21	29.73	1.30	4.4	31.42
Jan. 22-25	28.86	1.28	4.4	30.71
Jan. 26-29	27.33	1.24	4.5	29.49
Jan. 30-Feb. 2	27.42	1.30	4.7	30.47
Feb. 2- 6	26.98	1.25	4.6	29.61
Period II—High Fat Ration				
Feb. 7-10	29.22	1.44	4.9	32.84
Feb. 11-14	30.97	1.47	4.7	34.44
Feb. 15-18	32.53	1.51	4.6	35.66
Feb. 19-22	33.68	1.50	4.4	35.94
Feb. 23-26	33.37	1.36	4.1	33.78
Feb. 27-Mar. 1	33.29	1.33	4.0	33.27
Period III—Low Fat Ration				
Mar. 2- 5	33.54	1.14	3.4	30.48
Mar. 6- 9	29.91	1.13	3.8	28.99
Mar. 10-13	28.47	1.10	3.8	27.85
Mar. 14-17	26.05	1.07	4.1	26.47
Mar. 18-21	25.35	1.05	4.1	25.85
Mar. 22-25	23.96	1.05	4.4	25.37

daily butterfat production. The soybean oil was added to the hay and beet pulp. The results are shown in Tables 3 and 4 and in Fig. 1.

At the end of the third period three of the cows in Group A (cows 171, 245, and 66) and three of the cows in Group B (cows 218, 242, and 101) were continued on experiment. Cow 7 of Group A and cow

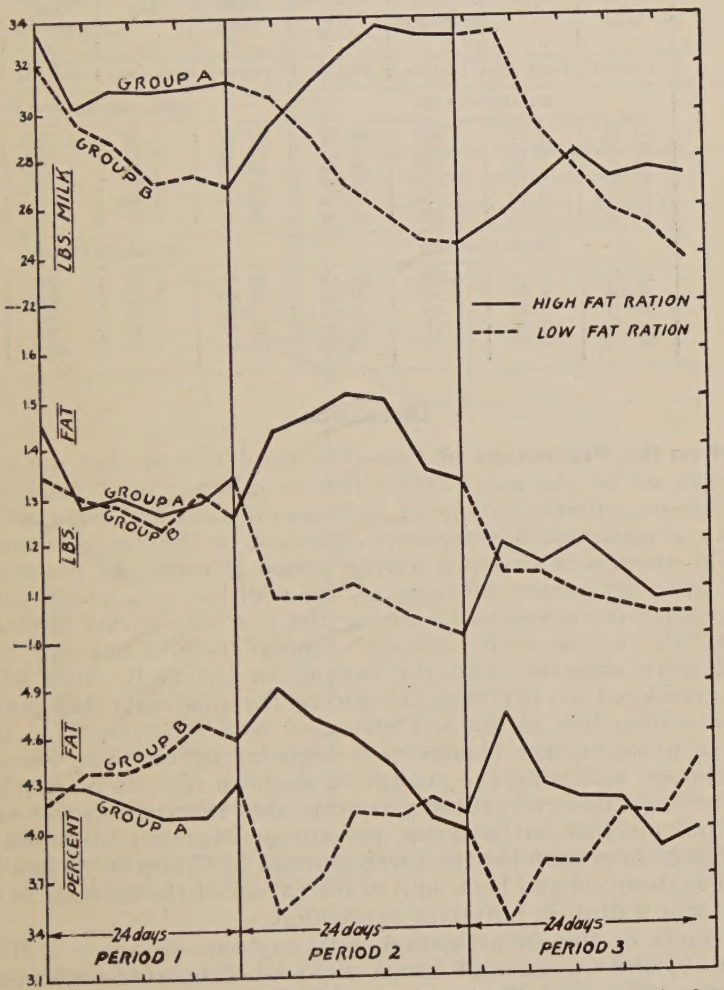

Fig. 1. The effect of adding soybean oil to a ration low in fat on milk production and the percentage of fat in milk.

99 of Group B were not used owing to the development of acute mastitis. The beet pulp and soybean oil were replaced with an isodynamic amount of corn in Group A; while in Group B, which received the low-fat ration during period III, the beet pulp was replaced by an isodynamic amount of barley. The results are shown in Table 5 and Fig. 2. Body weights were not significantly affected.

Table 5. Effect of replacing beet pulp with corn in a low-fat ration and beet pulp and soybean oil with barley in a high-fat ration.

Periods	Group B				Group A			
	Average Daily Milk	Fat	Average Daily Butterfat	Average Daily 4% F.C.M.	Average Daily Milk	Fat	Average Daily Butterfat	Average Daily 4% F.C.M.
	Pounds	Per Cent	Pounds	Pounds	Pounds	Per Cent	Pounds	Pounds
	Basal low in fat				Basal plus soybean oil			
1	34.42	3.14	1.083	30.02	27.29	4.38	1.197	28.87
2	31.43	3.41	1.073	28.67	29.11	3.95	1.153	28.94
3	30.47	3.60	1.097	28.64	30.80	3.93	1.213	30.52
4	28.01	3.77	1.057	27.05	29.64	3.90	1.157	29.21
5	27.62	3.80	1.050	26.80	29.96	3.58	1.073	28.15
6	25.15	4.01	1.010	25.18	30.05	3.70	1.110	29.69
	Basal plus corn				Basal plus barley			
7	27.72	3.99	1.107	24.83	30.51	3.20	.990	30.21
8	30.58	3.94	1.207	30.30	28.60	3.30	.943	25.59
9	30.81	3.84	1.183	30.08	27.29	3.40	.937	24.99
10	29.50	3.86	1.140	28.90	25.87	3.40	.903	23.86
11	30.34	3.89	1.183	29.89	26.06	3.70	.963	24.95

Discussion

Effect on the Percentage of Fat—The results show that the addition of soybean oil to the basal ration low in ether extract (alfalfa, beet pulp, molasses, solvent-extracted soybean oil meal and bone meal) resulted in a pronounced temporary increase in the fat percentage in milk. The animals in Group A during period II tested 4.1 per cent during the four-day period previous to the addition of soybean oil. The fat percentage increased to 4.7 during the four-day period immediately following the soybean oil addition. Similar results but not so pronounced were observed with the animals in Group B. Milk of those animals averaged 4.6 per cent fat during the final four-day period on the basal ration low in fat and increased to 4.9 per cent fat for the four days following the change to a high-fat ration. The increase in fat percentage following the change to soybean oil was of short duration. The cows, however, showed considerable variation in this respect. This initial increase in butterfat percentage was not observed when corn replaced beet pulp for the three animals in Group A. When barley replaced soybean oil and beet pulp in the ration of the animals in Group B, there was a drop in butterfat percentage.

The results of this investigation with soybean oil agree with those of Allen (1) and Garner and Sanders (5) who reported an increase in the fat percentage in milk over a period of five or six days when various oils were added to a ration low in ether extract. In the work here reported the increase in butterfat test lasted from four to about 12 days when the tests returned to normal and then decreased slightly below normal. The results with corn, however, are not in agreement with those of Allen. It appears that the temporary increase in butterfat percentage due to the addition of fat depends on the basal ration used. This may account for the results of M'Candlish and Struthers (3) and others who failed to observe an increase in butterfat percentage after the addition of fat.

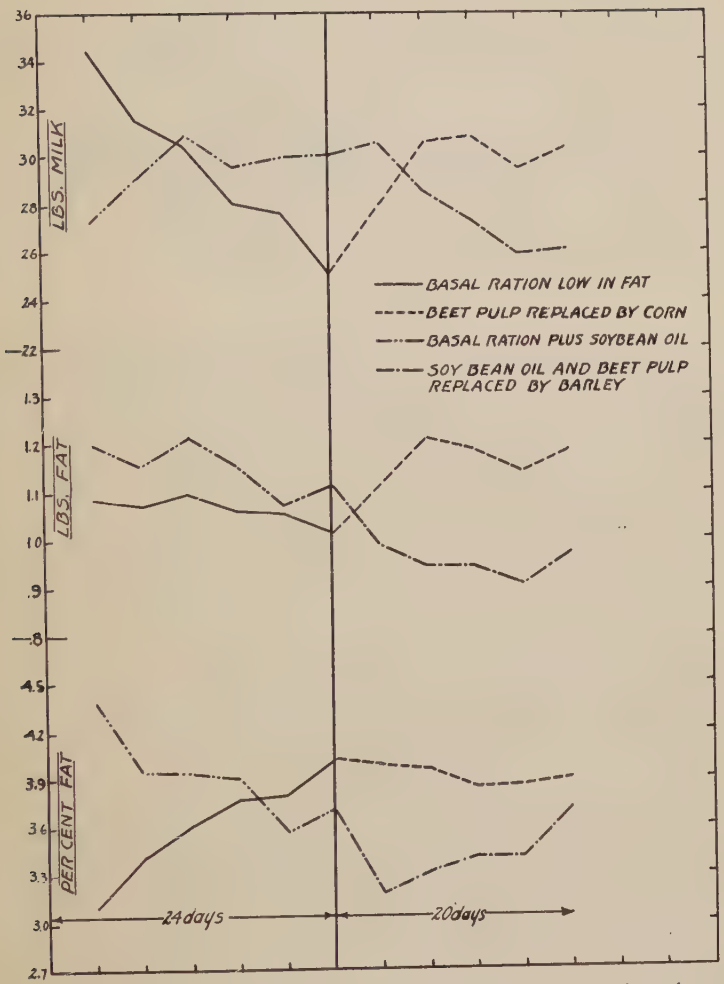

Fig. 2. The effect of replacing beet pulp with corn in a low-fat ration and the effect of replacing beet pulp and soybean oil with barley in a high-fat ration.

The effect of changing from the basal ration plus soybean oil to the basal ration low in fat resulted in a temporary drop in fat percentage, which was followed by a marked increase. Maynard and associates observed a similar increase in fat percentage on the low-fat ration which they used. Similar results were obtained when barley replaced soybean oil and beet pulp in the ration.

Effect on Milk Production

There was a decrease in milk production in both groups of cows when fed the ration low in fat. There was likewise an increase in milk when the animals were changed from the basal ration low in fat to soybean

oil. The increase was more marked in case of the animals in Group B. Similar results were obtained when corn replaced beet pulp in the basal ration.

When barley replaced soybean oil and beet pulp in the ration of the animals in Group B, there was a drop in milk production.

These results are in agreement with those of Maynard and associates who showed that a certain amount of food fat is essential for optimum milk production. In a previous work (6) the addition of fats to rations containing corn or corn silage failed to bring about an increase in either milk or the percentage of butterfat.

Summary

1. The addition of soybean oil in place of an isodynamic amount of beet pulp to the basal ration resulted in a temporary increase in butterfat percentage. This increase was of short duration and the fat percentage soon returned to normal.
2. The addition of soybean oil to the basal ration low in fat resulted in an increase in milk production.
3. When beet pulp was replaced by corn in the basal ration, there was an increase in milk production, but the fat percentage in the milk remained unchanged.
4. The feeding of a ration low in fat resulted in an increase in the percentage fat in milk.
5. The basal ration appears to be the important factor in determining the effect of the addition of fat on milk and fat secretion.

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PERMANENCE OF SIZE DIFFERENCES IN ORCHARD TREES

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The assumption has prevailed that most variations in size of bearing trees within one variety in an orchard can be attributed to local soil conditions such as depth and type of soil in the several horizons, soil drainage, soil fertility, or soil moisture supply, to the seedling stocks on which the varieties were worked, or to injuries of various kinds to the roots or trunks of the trees.

During the process of tabulating results of a long-time pruning experiment it became evident that certain trees which were smaller than their neighbors during the initial years in the orchard were much smaller than other trees at the end of a 15-year period. Likewise, certain trees that were larger than the average after planting in the orchard continued to remain larger than the average trees of the same variety. In view of the facts that the small individuals, as well as the large trees, seemed to be randomized rather than grouped throughout the orchard and that several investigators have reported size differences in fruit plants to be relatively permanent, it seemed advisable to subject the available data to a detailed statistical examination.

Bradford and Joley (1) recently found that there is a tendency for relatively small and large apple nursery seedlings and budded nursery trees to remain small or large, respectively, throughout the nursery growing period, and Tukey and Brase (4) state that the largest one-year whips of cherry and apple became the largest two-year trees in the nursery. Partridge and Veatch (2), working with grape vines of the Concord variety in commercial vineyards, report that vines which were weaker at the beginning of an experiment tended to remain relatively weak and that the stronger vines retained their lead throughout the term of the experiment whether they had been fertilized. Sax and Gowen (3) divided 208 apple trees into 13 classes based on tree trunk girths after they had been growing in the orchard two years and six years later found that the trees which were small at two years of age were relatively small six years later and that the largest trees in the young orchard maintained their superiority year after year.

Orchard Plan and Treatments

The orchard in which the trees under consideration are growing consists of five varieties of four rows each; originally there were nine trees in each row. This block of 180 trees was devoted to a pruning experiment designed to afford comparisons between different amounts of pruning. The trees of the first row of each of the five varieties were pruned severely each year from the time the trees were set in

1919 until they were 15 years old. All branches that did not appear to be essential to the development of a good tree (as generally interpreted at that time) were removed and some heading back was practiced, especially during the first five or six years of the experiment.

Except for the reduction of the number of lateral branches to five or six at time of planting, the trees in the second row of each variety were not pruned until the Duchess, Grimes and Stayman trees were 12 years old and the Baldwin and Northern Spy trees were 15 years of age (the end of the experiment). At the end of the twelfth, thirteenth and fourteenth seasons in the orchard, the Duchess, Grimes, and Stayman trees of these rows were given a corrective treatment designed to eliminate gradually the close crowding of scaffold branches and to remove branches which were too low for practical management of the orchard. Only two or three large limbs were removed each year.

The trees of the third row of each variety were subjected to a disbudding treatment two or three times during each of the first five seasons in the orchard, designed to reduce winter pruning by directing growth into buds at what appeared to be desirable locations. The spring and early summer disbudding were accompanied by a very light winter pruning. These trees were not pruned from the sixth to the fifteenth years, inclusive.

The fourth row of trees of each variety was given a light annual dormant season pruning. In severity, it was about midway between no pruning and the most severe treatment accorded the first row of each variety.

The trees were planted 20 feet apart in either direction and remained at that distance until the orchard had completed 15 years of growth when half of the trees were removed. Trunks of the latter provided the data for Table 3.

At the end of 15 years the missing trees from the original 180 consisted of one Grimes, two Stayman and three Northern Spy, two of the missing Northern Spy trees occurring in the fourth row.

The soil within the area devoted to any one variety is reasonably uniform. All of the orchard under consideration received similar cultural and fertilizer treatments. Some of the Northern Spy and some of the Stayman trees grew in locations that favored greater accumulation of soil moisture during rainfall than did the other locations for trees of these varieties.

Methods for Determination of Relative Size of Trees

The three methods employed for the determination of relative sizes of trees in the orchard are described in the following paragraphs.

Trunk circumference measurements for all trees in the orchard were made at the end of each growing season except the first, seventh, and twelfth years. Cross-sectional areas of the tree trunks were calculated from the circumference measurements for presentation in this article.

From the time the trees in the orchard under consideration were two years old until the end of the pruning experiment the spread of the branches of the trees was measured in two directions, i.e., the diameters of the tree tops were determined for two directions, and the average of the two measurements is assumed to give a fair measure-

ment of the average spread of the trees. The distance from the point of origin of the lowest main branch on the tree trunk to the tip of the highest twig on the tree was measured annually for each tree. Tree top volumes were calculated by the following equation: $V=K \cdot H \cdot \pi \cdot R^2$, in which V is the volume of the tree top in terms of cubic feet; H is the height from the point of origin of the lowest branch to the tip of the highest branch; R is the horizontal radius of a tree; and K is a factor indicative of the extent to which a tree top occupies or fills a solid cylinder. The value for K was calculated for each variety from measurements of many photographs, and it varied from 0.64 in the case of Stayman trees to 0.67 for Grimes and Baldwin trees.*

At the time the filler trees were removed from the orchard, sections of tree trunks about ten inches from the ground line were saved and the widths of the annual rings from time of planting to the completion of the fifteenth growing season in the orchard were measured on two radii and averaged for presentation in Table 3.

Selection of Trees for Size Classification

The nine trees in each row were ranked for size on the basis of cross-sectional areas of tree trunks at the end of the second season in the orchard (the earliest record of this kind available) and the trees of each row were also ranked according to tree size on the basis of tree top volumes at the end of the second season in the orchard, or in cases of ties, the ranking was determined at the end of the third season. Classification on the basis of width of annual rings was omitted from consideration because this involved only the trees that were removed in thinning the orchard. In general, the trees that were smallest or largest as measured by one method were also smallest or largest as measured by the other. In the several cases where the two criteria for size of trees failed to place the same individuals in the same size classes, the writer weighted the rankings for each method of measurement to arrive at a classification.

The nine trees of each row were divided into three classes: the smallest three trees at the time they were two years old constituted the trees designated as "small" in the tables, the three largest trees made a second class designated as "large," and the remaining trees of the row constituted a class intermediate in size and are not considered in this report.

Comparisons of Rates of Growth on Basis of Cross-sectional Areas of Tree Trunks

The average cross-sectional areas of the trunks for the three trees that were smallest and the three trees that were largest in each row of each variety and the averages for 12 trees in each size group for each variety at the completion of 2, 5, 8, 11, and 15 years in the orchard are presented in Table 1. In every case the three trees that were smallest at the end of the second year in the orchard remained smaller than

*The average measurements for eight photographs of trees of the Duchess variety of the same age were as follows: vertical area of tree as determined by planimeter = 10.13 sq. ins.; tree width or spread = 4.03 ins.; height from point of origin of lowest branch to top of tree = 3.83 ins. K = (10.13 ÷ 4.03) ÷ 3.83 = 0.66.

Table 1. Average cross-sectional areas of tree trunks in square inches of three smallest and three largest trees in each row of nine original trees. Classification based on cross-sectional areas and tree top volumes at end of second season in orchard.

Orchard Age of Trees in Years		2		5		8		11		15	
Variety	Row No.	Size Classification of Trees									
		Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
Duchess	1	0.5	0.7	2.3	4.0	9	12	15	22	26	38
	2	0.7	1.0	3.6	5.4	12	17	22	29	36	48
	3	0.5	0.8	3.2	4.3	11	13	20	25	34	40
	4	0.4	0.8	3.1	4.9	12	16	23	29	37	45
	Average	0.5	0.8	3.1	4.6	11	15*	20	26	33	43
Grimes	1	0.7	0.9	5.0	5.6	16	17	28	31	45	47
	2	0.7	0.9	4.6	5.9	15	17	27	30	43	46
	3	0.7	1.2	4.6	6.2	15	16	26	29	41	45
	4	0.6	0.9	5.0	6.7	16	18	28	32	42	47
	Average	0.7	1.0	4.8	6.1	15	17	27	31*	43	46
Baldwin	1	0.8	0.9	3.8	6.7	13	20	26	34	39	53
	2	0.8	0.9	4.5	7.6	15	23	31	42	44	60
	3	0.6	1.0	4.4	5.9	17	23	34	43	51	60
	4	0.7	0.9	4.3	6.0	16	22	29	41	41	57
	Average	0.7	0.9	4.2*	6.6	15	22	30	40	44	58*
Stayman	1	0.5	1.0	3.9	6.1	14	19	24	32	38	44
	2	0.8	1.1	5.1	6.6	18	19	33	34	46	51
	3	0.6	1.0	5.1	6.5	17	20	32	35	49	51
	4	0.8	1.1	5.0	6.9	16	20	30	36	47	55
	Average	0.7	1.1	4.8	6.5	16	19*	30	34	45	50
Northern Spy	1	0.5	0.9	4.2	6.4	11	18	19	32	30	51
	2	0.8	0.9	6.0	7.5	18	21	28	37	46	53
	3	0.5	1.0	5.1	6.6	15	19	29	35	46	55
	4	0.6	0.8	4.8	6.0	16	17	32	29	49	46
	Average	0.6	0.9	5.0	6.6	15	19	27	33	43	51
AVERAGE		0.6	0.9	4.4	6.1	14	18	27	33	42	50

*There may appear to be some inconsistencies in rounding averages in this and other tables. For instance, the small Baldwin trees at age 5 would appear to give an average cross-sectional area of 4.25, which should be rounded to 4.3 rather than 4.2. The figures actually averaged, however, were 3.80, 4.50, 4.42 and 4.26, giving an average of 4.24, which is rounded to 4.2.

the trees that were largest at the end of two years. In other words, trees that were small shortly after the orchard was planted were, on the average, destined to remain smaller than neighboring trees; trees that were larger than the average in the young orchard were still the largest trees when the orchard was 15 years old.

The averages for each variety are presented even though there may be some question as to whether it is technically correct to attempt to average trees that have been subjected to four different pruning treatments that have resulted in considerable differences in growth response. All of the differences between the average size of trees for each of the five varieties and in each of the years designated are statistically significant despite the high probable errors due to differences in growth response caused by pruning treatments, except the following: Grimes at the end of the fifteenth year, Stayman at the end of the eleventh and fifteenth years, and Northern Spy at the end of the fifteenth year.

The general averages for the five varieties afford an easier comparison of tree sizes of the two classes at the various ages. All of these differences between trees of the same age are highly significant. At the completion of 15 seasons in the orchard the third of the trees that were classified as large shortly after the orchard was established were nearly 20 per cent larger, according to this method of measurement, than the third constituting the small class.*

Figure 1 presents essentially the same information as the last line of Table 1 except that the available data for the intervening years have been incorporated. This graph shows that not only do the trees that are small when young continue to remain smaller than their neighbors but that the relative differences in tree sizes (in terms of time required to grow the difference in size of trees) tend to increase. When these varieties were ten years old, the trees that were largest at two years of age were approximately one growth year larger than the trees that were originally classified as small. By the time that this orchard was 15 years old, the trees that were largest at two years were nearly one and one-half growing seasons ahead of the poorer group as expressed by cross-sectional areas of tree trunks.

The orchard completed 20 seasons growth in 1938. Five years earlier one-half of the trees were removed in the process of orchard thinning and during the five-year period two Baldwin trees of the "large" classification were removed because of winter injury. At the end of the 1938 growing season, 30 of the 72 trees that were classified as small when two years old and likewise 30 of the 72 trees that were classified as large remained. In most cases one or two of the original three trees of each classification remained in a row, though in one row of Baldwin none of the small trees remained and in another row of Baldwin and in one row of Duchess none of the large trees remained. In only one row of Duchess were the three trees that were classified as large available for measurement in the fall of 1938.

*Inasmuch as the general averages show that the large trees were 50 per cent larger than those of the small class at two years of age, and the percentage differences tend to decrease with increase in age of trees, it might be contended that size differences tend to disappear with increase in the age were it not for the fact that such reasoning is fallacious. A 20 per cent difference in size of trees at 20 years of age represents a greater difference in growing time and capacity to function than a 50 per cent difference at two years of age.

Obviously, comparisons of tree size as indicated by cross-sectional areas of tree trunks within individual rows would have little significance under such conditions. Differences in pruning treatments of the four rows of each variety and the lack of uniformity in numbers of trees of each row that can be averaged make the differences that exist between averages within a variety of less significance than those that have been presented in preceding paragraphs. Nevertheless, these averages for varieties are presented for what they may be worth.

The average cross-sectional areas of tree trunks in square inches at the time the orchard was 20 years old for trees classified as small and for those classified as large, respectively, are as follows: Duchess, 53 and 60; Grimes, 67 and 72; Baldwin, 69 and 106; Stayman, 65 and 71; and Northern Spy, 69 and 83. When all varieties are averaged, the trees that were classified as small at two years from planting time have 66 square inches of cross-sectional trunk area while those that were classified as large have an average area of 76 square inches. The differences in average size of trees of each variety and for the group as a whole, as expressed in percentages, remain essentially the same at 20 years of age as at 15 years from planting. Thus, the limited data available at the time the orchard was 20 years old indicates that differences in size of trees at two years of age remained permanent.

Comparisons of Rates of Growth on Basis of Tree Top Volumes

Table 2 shows the average annual rate of increase in tree top volumes for the trees classified as small and as large for each variety. Obviously, such a table would be too voluminous if attempts were made to show the size of trees of each classification for each row of each variety for each of 14 years. Each figure presented in all but the last two columns is an average for 12 trees. The 12 trees, in the case of the small classification, consist of the three smallest trees of Row 1, the three smallest of Row 2, the three smallest of Row 3 and the three smallest of Row 4, rather than the 12 smallest of a possible 36 trees irrespective of pruning treatments. The trees composing these groups are identical with those used for Table 1.

In all but the last two columns, the figures have been rounded to the nearest unit of ten when the volumes exceeded 150 cubic feet and to the nearest unit of 100 when the volumes exceeded 2,000 cubic feet.

A few instances will be noted in which the trees were apparently smaller one season than one year earlier. These trees were standing 20 feet apart until the termination of the experiment, that was designed to compare differences in severity of pruning. Therefore, even a thinning-out type of pruning might reduce the spread or height of a tree materially and, in addition, occasional heading back was practiced to facilitate orchard operations.

The tendency for trees that were small, when the orchard was young, to remain relatively smaller than the trees that were initially classified as large is much the same as that found in Table 1. In every instance, the average of 12 trees classified as small continued to average smaller in tree top volume than did the 12 trees classified as large. In the cases of Grimes and Stayman, the average differences in size are not

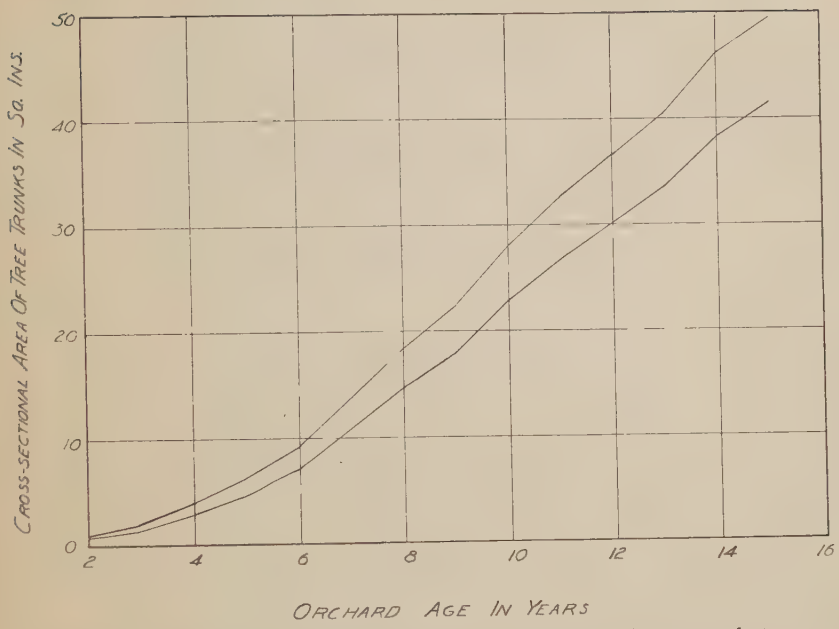

Fig. 1. The lower line shows the rate of growth of the trees that were classified as smallest of their respective rows at two years of age and the upper line shows the rate of growth for the trees classified as large. Each line represents an average for 60 trees of five varieties.

great but they are, nevertheless, rather consistent. Much the same condition is evident in Table 1.

The figures presented in the last two columns of Table 2 are averages of the figures appearing in the preceding columns. All differences for trees of the same ages in those columns are statistically significant even though each size classification is composed of trees subjected to different pruning treatments that resulted in different growth responses.

Comparisons of Rates of Growth on Basis of Annual Ring Increments

Inasmuch as there were nine original trees in each row and alternate trees were removed at the end of 15 years, not to exceed four tree trunks would be available in half the rows and not more than five tree trunks in the other rows for sectioning. It was therefore decided to select the one tree of four or five in each row that was smallest at time of planting for the "small" class and the one that was largest for the "large" class. These trees were chosen without reference to the classification for preceding tables. Four trees, one from each row of a variety, were averaged to give the figures for each size classification presented in Table 3.

This method of comparing the rates of growth of the trees shows that size differences that were apparent at planting time have persisted throughout the 15-year period for which data are available. There is some indication that the differences in rates of growth between the

Table 2. Tree top volumes in cubic feet. Averages of three smallest and three largest of nine trees in each of four rows per variety. Size classification made at end of second growing season in orchards.

Variety	Duchess		Grimes		Baldwin		Stayman		Northern Spy		Average	
Orchard Age of Trees in Years	Size Classification of Trees											
	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
2	5	8	10	21	8	15	24	37	6	10	10	18
3	13	28	24	42	21	45	47	73	15	23	24	42
4	33	73	88	130	58	115	160	210	48	75	79	122
5	76	140	130	190	140	210	290	370	86	140	143	212
6	170	260	310	400	290	440	570	720	180	250	303	414
7	270	410	490	640	410	630	890	1,020	280	390	467	634
8	440	660	780	1,010	680	1,000	1,320	1,520	450	620	736	960
9	600	810	1,020	1,240	940	1,290	1,650	1,840	730	900	985	1,260
10	810	1,120	1,360	1,550	1,260	1,730	2,000	2,200	980	1,250	1,285	1,580
11	1,320	1,710	1,890	2,100	1,820	2,500	2,600	2,800	1,460	1,770	1,820	2,190
12	1,690	2,200	2,200	2,600	2,600	3,400	3,600	3,700	1,860	2,200	2,390	2,830
13	2,000	2,500	2,500	2,800	2,400	3,300	3,700	3,900	2,300	2,700	2,580	3,050
14	2,200	2,900	3,000	3,500	3,100	4,200	4,100	4,400	3,000	3,700	3,080	3,720
15	2,900	3,700	3,700	4,000	3,600	5,000	4,800	5,300	3,900	4,600	3,790	4,520

small and large Duchess, Stayman and Northern Spy trees have increased with age of trees, that the differences in the case of Grimes have merely persisted, and that the differences between the two classes of trees widened for a time in the case of Baldwin, followed by a narrowing of differences. The numbers of trees involved, however, are not great enough to warrant the placing of a great amount of emphasis on these apparent trends. The data are valuable to the extent that they substantiate the two preceding tables.

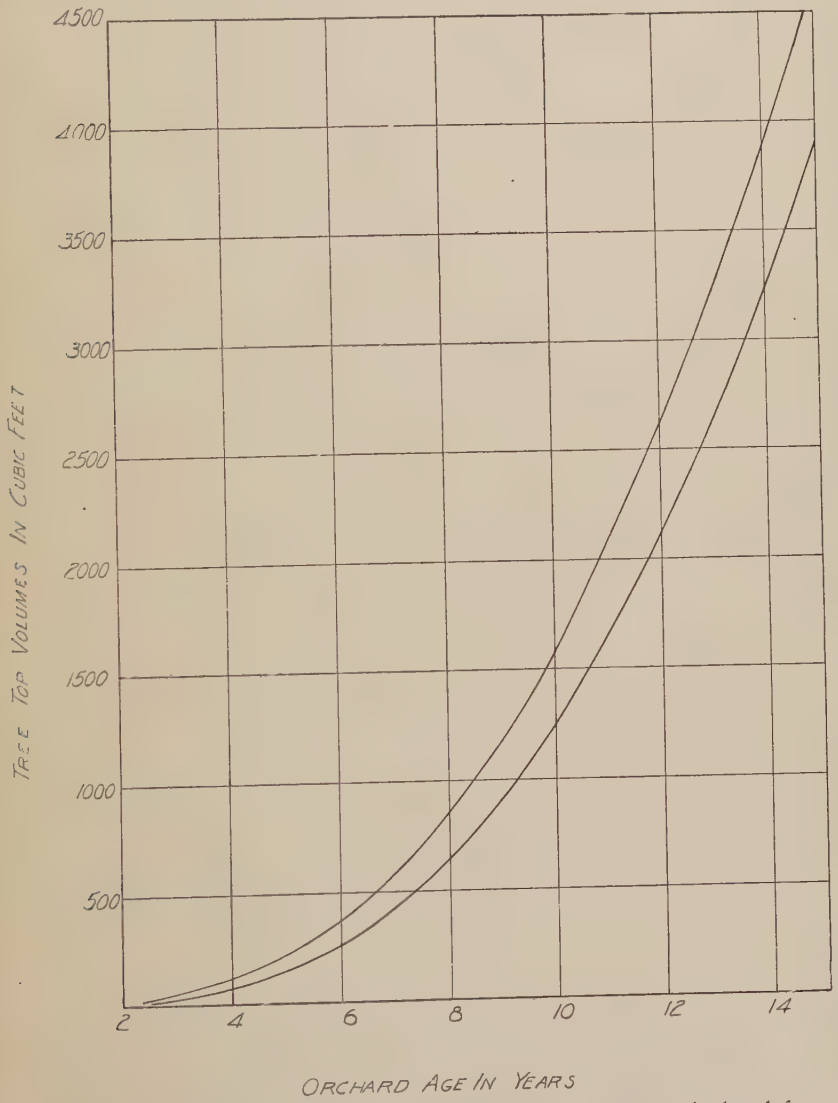

Fig. 2. Rate of growth curves for small and large trees, calculated from data presented in the last two columns of Table 2. The trees that were small at two years of age were approximately one growth year smaller than the trees of the large group when the orchard was 12 to 15 years old.

Table 3. Average radial increases in terms of accumulated totals for the smallest and the largest filler tree of each of four rows for each variety. Classification based on thickness of woody portion of stem at time of planting.
(Millimeters)

Variety.....	Duchess		Grimes		Baldwin		Stayman		Northern Spy		Average	
Orchard Age of Trees in Years	Size Classification of Trees											
	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
1.....	2	3	2	4	2	3	3	3	2	3	2	3
2.....	4	7	6	8	5	8	6	8	6	8	5	8
3.....	7	13	12	14	8	13	11	14	12	15	10	14
4.....	12	19	19	21	13	21	18	22	20	23	16	21
5.....	17	25	26	28	21	28	25	29	26	30	23	27
6.....	23	32	33	35	28	36	32	37	32	36	30	35
7.....	28	39	41	44	38	45	41	46	40	45	38	44
8.....	35	46	47	50	47	53	49	54	48	53	45	50
9.....	39	50	54	57	54	60	56	62	54	59	51	57
10.....	45	58	61	64	62	68	64	70	62	67	59	65
11.....	50	64	66	70	68	74	70	76	68	72	64	71
12.....	54	69	71	75	72	78	74	82	72	77	69	76
13.....	57	72	75	78	77	83	79	87	77	83	73	80
14.....	64	78	82	84	82	87	84	92	82	88	79	85
15.....	66	81	85	87	85	89	87	95	85	92	82	88

Initial Size Differences May Not Remain Permanent

The data presented thus far have been averages for 3 to 12 trees per variety or, in the case of general averages, for 20 to 60 trees. As might be expected, there were a few individual trees classified as small when they were young that grew as rapidly or even faster than trees in the same row classified as large and *vice versa*.

One of the Stayman trees of Row 2 (unpruned) was classified as one of the three largest trees of the row at two years of age. After 15 years in the orchard it showed a cross-sectional area for the trunk of 44 sq. ins. compared with 46 sq. ins. for the average of the three trees originally classified as small and a tree top volume of 4,550 cubic feet compared with an average of 4,800 for the three small trees. Even though this Stayman tree had what appeared to be potential possibilities of becoming one of the three largest trees in the row, it actually became the third smallest tree of the row as measured in terms of the tree trunk and next to the smallest tree as measured in terms of tree top volume.

One of the Northern Spy trees of Row 4 that was the largest one of the row in terms of both trunk measurement and tree top volume actually became the smallest tree in the row by both criteria of size when the orchard reached an age of 15 years. This individual maintained its lead over all other trees in the row for five years and then began to decline in rate of growth. The behavior of this one tree was such as to make the average difference in size for this variety hardly significant, statistically, at 15 years of age.

One of the Grimes trees of Row 4 was the smallest tree of this row at the end of the second season in volume of top and was one of the two smallest as determined by trunk measurement. At the time the orchard was 15 years old, the tree had a trunk cross-sectional area of 47 sq. ins., which is equivalent to the average for the three trees of the row classified as large and the volume for the tree top was calculated at 4,600 cubic feet, which is the largest tree top volume for that row and the fourth largest for all Grimes trees.

The foregoing instances have been cited to explain that some individuals that were vigorous growing in the nursery or immediately after planting may become weak or small trees in later years and those that are apparently weak in the young orchard may become strong growing trees. Such deviations from the normal trend of weak trees to remain relatively weak ones and for large trees at least to retain their growth leads may be explained by very local soil environments, winter and other types of injuries, root stocks and other factors mentioned in the first paragraph of this paper.

Discussion

The data presented in tabular and graphical form show that, on the average, trees that are smaller than the average when the orchard is two years old are likely to remain smaller than the average and that large trees in the young orchard may be expected to develop bearing trees that are larger than the average and therefore have greater bearing capacity.

Other data (Table 3) indicate that trees showing large caliper at the time of planting the orchard are likely to become the larger trees

in the bearing orchard. In other words, size differences, within certain limits, at planting time are likely to remain permanent in the orchard.

No information is available to show the size (nursery grade) of the trees that were delivered from the nursery for the planting of this orchard. It may be assumed, however, that well grown nursery stock, reasonably uniform and perhaps above average size was requested and delivered for a planting that was destined for experimental use. In such a case, the range in sizes, as indicated by height of tree or caliper of tree trunk, would not be great. The data presented in this paper then must not be interpreted as a comparison between rates of growth of trees from two different nursery grades but rather between trees within one size grade where there was probably not to exceed one foot difference in height between the smallest and largest trees of a variety. One might estimate, on the bases of data presented by Bradford and Joley (1) and in this article, that bearing orchard trees grown from two-year nursery trees of the 5- to 6-foot grade would be very much larger than those grown from 4- to 5-foot trees and that one would never be justified in planting the smaller two-year stocks. One-year nursery apple trees are offered by some nurserymen in several size grades such as 2 to 3 feet, 3 to 4 feet, 4 to 5 feet and sometimes 5 to 6 feet. If differences in rates of growth in the orchard are substantial between trees within the same size grade, there must be very great differences in growth response in the orchard following the setting of trees from 2- to 3-foot nursery stock and 5- to 6-foot stock.

The data presented indicate that the larger the size of the nursery stock planted, the larger will be the trees in the bearing orchard. There were probably no very large nursery trees planted in this block. It may be assumed that the larger of the trees planted in this orchard would be termed medium large or above medium in size. Whether there is an upper size limit for nursery grown apple trees, above which size the trees fail to maintain the faster growth rates, is not known.

In general, one must conclude that when the grower is offered a choice of sizes of nursery trees for planting for commercial purposes the larger trees should be procured, even at some price premium, for such trees may be expected to be one or more years larger in size and bearing capacity at 10 to 15 years of age and a few more apples in any one of those years will more than compensate for the original price differences for nursery stock.

Twenty-five dollars per acre per year is not considered a high rate of increase in value of well located young apple orchards. If an orchard at 15 years of age is one or two growth years smaller than another planted at the same time, it represents an inventory value of $25 to $50 or more less per acre. These values should be borne in mind when selecting or ordering nursery stock.

Summary

The nine trees in each of 20 rows involving five varieties of apples were divided into three size groups on the bases of cross-sectional areas of tree trunks and tree top volumes after the completion of two growing seasons in the orchard and the relative rates of growth of

the trees constituting the smallest trees and the class of largest trees were determined until the orchard was 15 years old.

On the average, the small trees remained substantially smaller in size as determined by rate of tree trunk growth and rate of tree top volume increases, than the large trees throughout the 15-year period and there was some indication of a tendency for the relative size differences between small and large trees to increase with increase in age of trees.

Filler trees were removed at the end of 15 years and a study of annual ring increments showed that the smallest filler tree of each row at planting time was, on the average, the smallest tree when the orchard was 15 years old and that the largest filler tree of each row at planting time was the largest at the end of the experiment.

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SPRAY TRIALS ON ORNAMENTAL RED CEDARS

F. C. STRONG AND E. J. RASMUSSEN
SECTIONS OF BOTANY AND HORTICULTURE

The cedar-apple and cedar-hawthorn rust diseases caused by *Gymnosporangium spp.* are becoming of increasing importance in commercial ornamental tree nurseries and on public and private grounds such as parks, cemeteries, estates, where susceptible species and varieties of crabapple, flowering apple and hawthorns are planted in close proximity to susceptible varieties of the red cedar. The close association of these two alternate host groups of the cedar-apple and cedar-hawthorn rust fungi permits the increase in number of infections year after year until these trees become very unsightly and considerable injury results.

These rusts can best be controlled by removal of one of the host groups, preferably the red cedar, *Juniperus virginiana* and its susceptible varieties to a distance of one mile from pomaceous host trees. While this practice is applicable with orchard trees, it encounters difficulties when applied to the landscaping of grounds for ornamental purposes. A nurseryman who grows both red cedars and ornamental apples and hawthorns often finds it impossible because of lack of sufficient land to make the separation. There is also the problem of adjacent property owners who may be growing one or the other of the alternate host groups.

A second method of control is the use of the more resistant varieties of flowering apples, crab apples and hawthorns and the more resistant varieties of red cedar when planting these two tree groups near to each other. Many of the favorite varieties for landscape beautification are unfortunately very susceptible to these rusts.

A third method of control is by the use of fungicidal sprays applied to one or the other or to both host groups. MacLachlan and Crowell* have worked out a successful spray program to control these diseases in the vicinity of Boston using sulphur spray at the proper time of year on each of the respective host groups.

In preliminary trials in the vicinity of Lansing, Mich., during the summer of 1938 red cedar trees were sprayed with Dow Mike,** a wettable sulphur alone and with the three different stickers added to determine whether this sulphur compound could be used without injury to the foliage and whether these stickers were of any value in increasing the effectiveness of the sulphur spray.

The 81 red cedar trees sprayed were of the following varieties and sizes:

Juniperus virginiana	15 trees	4 to 25	feet high
Juniperus virginiana var. *Canaertii*	28 trees	3 to 8	feet high
Juniperus virginiana var. *glauca*	24 trees	3 to 6	feet high
Juniperus virginiana var. *elegantissima*	8 trees	2 to 4	feet high
Juniperus virginiana var. *Burkii*	6 trees	3 to 4	feet high

An equal number of unsprayed trees of all varieties were held as controls.

The following combinations of spray materials were used to make 100 gallons of spray:

Dow Mike sulphur 6 pounds plus soybean oil*** 1 quart.
Dow Mike sulphur 6 pounds plus soybean flour*** 3 pounds.
Dow Mike sulphur 6 pounds plus Orthex**** 1 pint.
Dow Mike sulphur 6 pounds with no sticker.

Five spray applications were made at three week intervals beginning June 15th and continuing until September 8th.

Since at least 12 months must elapse from infection before the galls become visible on the red cedar trees it is impossible to determine at this time how effective these spray treatments were in controlling infection. However injuries to foliage by these treatments may be reported.

Observations of the sprayed trees made in September and October 1938 and again in April 1939 show that the foliage of *Juniperus virginiana* var. *Burkii* was turned yellow when soybean oil was used as a sticker. A very slight amount of yellowing was apparent on two *Juniperus virginiana* var. *Canaertii* trees when sprayed with this combination. Compared with unsprayed control trees, all other combinations of Dow Mike sulphur and stickers and Dow Mike sulphur alone showed no apparent injury.

Sulphur injury is associated with high temperatures. The year 1938 was not favorable for sulphur injury as shown by the following highest

*J. D. MacLachlan and I. H. Crowell. Control of Gymnosporangium rusts by means of sulphur sprays. Jour. Arnold Arboretum **18** (2): 149-163. 1937.
**Dow Chemical Co., Midland, Mich.
***Allied Mills, Chicago, Ill.
****California Spray Chemicals Co., Richmond, Calif.

temperatures and their respective dates taken from the records of the Weather Bureau at East Lansing:

June 24th	91°F.	Aug. 5th	90°F.
July 7th	89°F.	Aug. 14th	90°F.
Aug. 2d	90°F.	Sept. 12th	83°F.
Aug. 3d	91°F.	Sept. 26th	82°F.

Since weather conditions in 1938 were unfavorable for sulphur injury no definite conclusions can be drawn as to possible foliage injury by wettable sulphur. However it may be emphasized that soybean oil cannot be recommended as a sticker for wettable sulphur sprays on red cedar since it caused distinct injury to foliage of two varieties in this test.

SPELT EQUALS OATS FOR PIGS

V. A. FREEMAN
Section of Animal Husbandry

Results from one trial indicate that winter spelt is about equal to oats for feeding pigs.

Four lots of six fall pigs each were fed to compare the feeding value of spelt with oats during the winter of 1938-39. Because of the high fibre content of both feeds, corn was added, Lot 1 receiving 50 per cent spelt and 50 per cent corn, Lot 2 receiving 25 per cent spelt and 75 per cent corn, Lot 3, 50 per cent oats and 50 per cent corn, and Lot 4, 25 per cent oats and 75 per cent corn. All lots received the same supplement which was composed of 40 pounds of tankage, 30 pounds of soybean oil meal, 20 pounds of ground high-quality alfalfa, and 10 pounds of dried skimmilk. The grains were mixed and fed in one compartment of the feeder and the supplement fed in another compartment, the pigs having free access to both. All lots had access to self-waterers and a mineral mixture made up of equal parts of steamed feeding bonemeal, finely ground limestone, and salt. Very small amounts of the mineral were taken by any of the lots.

The record of the gain, average daily ration and feed required per hundredweight of gain are given in the accompanying table.

The pigs averaged approximately 72 pounds at the beginning of the experiment, and individual pigs were taken out of the lots as fast as they reached approximately 200 pounds of weight. The pigs in Lot 1, receiving equal parts of spelt and corn, made the highest rate of gain, averaging 1.37 pounds per head daily as compared with 1.3 pounds for Lot 2, 1.21 pounds for Lot 3, and 1.28 pounds for Lot 4. Both lots fed spelt and corn consumed somewhat more supplement than did the lots fed oats and corn. Lot 4, receiving 25 per cent oats and 75 per cent corn, failed to take more supplement than did Lot 3, as one would expect, and this may account for Lot 4 not showing more efficiency in gain than Lot 3.

Table 1. Spelt versus oats for pigs.

Lot Number	1	2	3	4
Grains used (supplement was self-fed free choice in each lot)	Spelt 50% Corn 50%	Spelt 25% Corn 75%	Oats 50% Corn 50%	Oats 25% Corn 75%
Average initial weight of pigs	73 lb.	71.4 lb.	72.5 lb.	73 lb.
Average final weight of pigs	194.3	189.3	188.7	193
Average daily gain	1.37	1.30	1.21	1.28
Average daily ration:				
Grain	4.92	4.06	4.15	4.45
Supplement	1.04	1.06	.91	.9
Total	5.96	5.12	5.06	5.35
Feeds fed per 100 lb. gain:				
Ground spelt	179 lb.	78 lb.		
Ground corn	179	235	171 lb.	87 lb.
Ground oats			171	261
Supplement	76	82	75	70
Total	434 lb.	395 lb.	417 lb.	418 lb.

There was a small difference in the total amount of feed per 100 pounds of gain. The greatest amount of feed for gains was required by Lot 1, fed 50 per cent spelt and 50 per cent corn, and the smallest amount was required by Lot 2, receiving the 25 per cent spelt and 75 per cent corn in their grain mixture. The two oat-fed lots were practically the same in total feed requirements and are just about half way between the two spelt-fed lots.

If the two spelt-fed lots are averaged together and the two oat-fed lots averaged together, one determines that 129.5 pounds of spelt, 206.6 pounds of corn and 78.8 pounds of supplement, or a total of 414.9 pounds, were required for each 100 pounds of gain by the spelt-fed pigs. Practically the same amounts of feed were required by the average of the two oat-fed lots, the average requirement being 128.4 pounds of oats, 216.9 pounds of corn, 72.8 pounds of supplement, or a total of 418.1 pounds. While the difference is too small to be significant, the oat-fed lots consumed an average of 6 pounds less supplement for each 100 pounds of gain and 10 pounds more corn, which would make the cost of gain practically equal for the two groups.

The chemical analyses of the spelt and oats used in this trial were as follows:

	Moisture	Protein	Crude Fiber
Spelt	11.76%	10.25%	11.38%
Oats	11.59	10.75	11.94

STARCH RESERVES IN THE ROOTS OF PASTURED ALFALFA WHEN GROWN ALONE AND IN MIXTURES

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The use of alfalfa alone or in mixture with certain grasses for pasture is becoming of increasing importance in Michigan, owing largely to the lack of succulent, nutritious feed on bluegrass* pastures during the hot dry weather of July and August. However, the management of such pastures in order to obtain the most desirable returns in livestock products and in the duration of life and productivity of the pasture plants has not been fully worked out. The life of a stand of a winter hardy variety of alfalfa is associated with reserve foods, especially starch, in the roots of the alfalfa plants as they reach the dormant season in the fall.

With a view to explaining some of the complex problems involved in grazing alfalfa or alfalfa grass mixtures, several one-acre duplicate plots were laid out in 1934 at the W. K. Kellogg Farm, a branch station of the Michigan Agricultural Experiment Station, located at Augusta, Mich. More particularly the experiments dealt with: (1) the response to grazing with sheep of alfalfa seeded alone or in mixture with grasses of different growth habits and palatabilities; (2) the reaction of alfalfa plants to grazing, in comparison to hay cutting practices, particularly with reference to accumulation of starch in the roots at different periods throughout the growing season; (3) the relationship of gains or losses in weight of sheep on alfalfa or alfalfa grass mixtures to starch accumulation in the roots of the alfalfa, and (4) the period during the grazing season in which alfalfa plants store up reserve starch.

The experiment was conducted on a Bellefontaine sandy loam soil which was limed for the correction of acidity and fertilized with 250 pounds of 0-8-24 fertilizer. The set of grass mixture plots was started in the fall of 1934, by sowing the grass seed with rye and the following spring Hardigan alfalfa was sown in the rye with an alfalfa drill. In another set of straight alfalfa plots, the soil was similarly treated and the alfalfa was sown with oats in the spring of 1935.

With a plentiful supply of rainfall in 1935, the rye made a vigorous growth and was cut with a mower just after it had headed. This left considerable volunteer growth of rye which later shattered some seed. Good stands of alfalfa were obtained in all cases.

*Kentucky and Canadian bluegrass are commonly called June grass in Michigan.

**Acknowledgments are due G. A. Brown and L. H. Blakeslee, Section of Animal Husbandry, for their cooperation throughout these experiments especially as regards selection and supervision of grazing animals; also C. M. McCrary, Superintendent of the W. K. Kellogg Farm of the Michigan State College, where the trials were conducted.

Because of volunteer rye in the set of alfalfa, and alfalfa grass mixture plots, grazing was not started in the spring of 1936, as was originally planned, but all of this set of plots was allowed to grow until the alfalfa was in full bloom, at which time they were cut for hay. This eliminated all of the rye, a fair second growth developed and it was pastured during July. Because of the severe drouth of 1936, the sheep were turned off the first of August and the pastures were not grazed until late September, at which time sheep were turned on and left on until about November 1. Of the two plots of straight alfalfa which were seeded with oats, one (Plot 6) was grazed from May 15 to August 28, and then grazing was discontinued and the other (Plot 14) was grazed continuously from May 15 until October 16. These two plots were used for further comparisons between the alfalfa-grass and straight alfalfa pastures.

The seedings of reed canary grass and tall oat grass were very spotted but excellent stands of alfalfa, alfalfa-orchard grass and alfalfa-smooth brome grass were obtained. The grazing during 1936 was largely of an observational nature and it was noted that sheep preferred alfalfa to the orchard grass and during October, the alfalfa was grazed more heavily in this mixture than in any of the others.

In the spring of 1937, indications were that opportunity would be afforded to get a satisfactory comparison between alfalfa alone, alfalfa-orchard grass and alfalfa-smooth brome grass mixtures. The stands of alfalfa-tall oat and alfalfa-reed canary grass were very spotted and were left and cut as a hay crop.

In the grazing tests, sheep were used and the following procedure was adopted—

Grazing was started on May 14 and the one-acre paddocks stocked as follows: Alfalfa-orchard grass, 5 ewes and 6 lambs; alfalfa-smooth brome grass, 5 ewes and 7 lambs; straight alfalfa, 5 ewes and 6 lambs. Paddock No. 6 was grazed with 5 ewes and 5 lambs and No. 14, with 5 ewes and 6 lambs. Both No. 6 and No. 14 were straight alfalfa seedings. The sheep and lambs were weighed separately before being turned on to the pastures and each two weeks thereafter. Some variations in stocking during the season were necessary and will be noted in Table 1.

Samples of alfalfa roots were collected two weeks previous to the start of grazing and at two-week intervals thereafter, coinciding with the dates on which the sheep were weighed from all of the paddocks reported on here and likewise from an adjacent plot which was seeded in the same manner and at the same time and subjected to ordinary hay cutting practices. The root samples each of approximately 20 roots were selected only insofar as any dead roots were thrown out, otherwise they were taken from several spots in the paddock. The roots were washed immediately and small sections of the roots, taken approximately 3-4 inches from the crown, were pickled in formalin alcohol solution for further study.

Experimental Data

Whereas duplicate paddocks were used in each case, it was thought advisable in this report to use the sheep weights from the paddocks from which the alfalfa root samples were taken. However, the sheep weights from the duplicates were in close agreement.

Table 1. The gains and losses made by ewes and lambs on various pastures by weighing periods during the pasture season of 1937.

Grazing Period	Alfalfa-orchard grass mixture Plot 1				Alfalfa-smooth brome grass mixture Plot 2				Alfafla alone Plot 5				Alfalfa alone Plot 6				Alfalfa alone Fall grazed September Plot 14			
	Ewes		Lambs		Ewes		Lambs		Ewes		Lambs		Ewes		Lambs		Ewes		Lambs	
	No.	Gain	No.	Gain	No.	Gain	No.	Gain	No.	Gain	No.	Gain	No.	Gain	No.	Gain	No.	Gain	No.	Gain
May 14-May 28	5	65	6	74	5	90	7	95	5	47	6	78	5	47	5	34	5	33	6	49
May 28-June 11	5	41	6	70	5	28	7	96	5	32	6	45	5	18	5	36	5	26	6	48
June 11-June 25	5	−66	6	2	4	−41	7	−45	5	−55	6	9	5	−28	5	16	5	−40	6	17
June 25-July 9	6	19	7	26	6	17	7	32	6	− 4	7	11	5	2	5	42	5	11	6	42
July 9-July 23	6	− 9	7	− 2	6	8	7	20	6	32	6	15	5	4	5	7	5	18	6	10
July 23-Aug. 6	6	− 5	7	8	6	9	7	34	6	− 9	6	5	5	50	5	42	5	25	6	30
Aug. 6-Aug. 20	7	−15	5	1	6	−28	5	− 8	6	−22	7	−14	5	−36	5	− 3	5	−26	6	9
Aug. 20-Sept. 1	7	1	–	——	6	− 3	–	——	6	20	–	——	7	−13	–	——	8	−29	–	——
Sept. 1-Sept. 17	–	——	–	——	–	——	–	——	–	——	–	——	–	——	–	——	8	5	–	——
Sept. 17-Oct. 1	–	——	–	——	–	——	–	——	–	——	–	——	–	——	–	——	8	−14	–	——
Sept. 24-Oct. 8	4	66	–	——	4	81	–	——	4	40	–	——	4	−42	–	——	–	——	–	——
Oct. 8-Oct. 24	4	2	–	——	4	2	–	——	4	1	–	——	–	——	–	——	–	——	–	——
Total ewe and lamb gains per acre		99		179		163		224		82		149		2		174		9		205
Total sheep days	1,057				1,039				1,032				854				1,120			
Total gain per acre				278				387				231				176				214

A study of Table 1 shows that, as a whole, ewes and lambs both gained the fastest during the first month of pasturing. During this period, the alfalfa was succulent and growing much faster than the sheep could consume the forage. During the third grazing period from June 11 to 25, the sheep, especially the mature ewes, lost considerable weight. The forage at this time was apparently in very good condition but observations on the mechanics of weighing sheep during all sorts of weather indicate that if the weighing is done just following or during a heavy rain the mature sheep as a rule lose weight rather than gain. This may account for the losses indicated on the June 25 weighing date for it rained over an inch the night and morning previous

Fig. 1. Photograph taken on July 20, 1937, showing alfalfa-brome grass mixture on the left and alfalfa-orchard grass on the right.

to weighing. On July 9, all the lots of sheep, both ewes and lambs, gained weight with the exception of the ewes on the straight alfalfa in plot 5. In all cases the lambs gained much more than the ewes during this two-week period. The following two-week period ending on July 23, brings out a point of interest. Both ewes and lambs lost on the alfalfa-orchard grass plot, while all of the rest of the paddocks were contributing gains in sheep weights. There was considerable orchard grass left on this plot on July 23, but it was headed out, mature and unpalatable as compared with the alfalfa. In this same paddock the alfalfa was scarcely noticeable because of extremely close grazing. The alfalfa-smooth brome plot was about 8-10 inches high at this time and grass and alfalfa were both grazed at the same level. Figure 1 shows this comparison on June 20, 1937. On August 6, the sheep on

plot 5 of straight alfalfa were beginning to show the effects of a lack of feed. The sheep on the alfalfa-orchard plots had considerable feed left but it was unpalatable and gains were slight. The alfalfa-brome plot was still contributing sufficient nutritious feed for gains as were plots 6 and 14, comprised of straight alfalfa, but the latter two plots were not stocked so heavily as was plot 5, also straight alfalfa. It was noticeable at this time also that plot 6 of straight alfalfa was almost a pure stand of alfalfa, while 14, which was grazed during September the previous fall, was beginning to show a considerable number of bluegrass patches. Plot 5 was becoming very weedy, the weeds being chiefly annual in nature such as ragweed and the annual foxtails.

On August 20, practically all of the lots of sheep lost weight, the ewes showing far heavier losses than the lambs. The succulent feed was becoming scarce at this time in all paddocks, and again rainfall was probably a complicating factor, as it rained 0.42 inch the morning of August 20. On August 20, the lambs were weaned and the ewes left on the paddocks. By September 1, the alfalfa-orchard grass paddock was beginning to grow seedling orchard grass plants from shattered seed and the sheep were grazing this growth, which may explain the fact that they held their weight on this plot. The brome-alfalfa pasture was beginning new growth from rains totaling 4.55 inches on the 17th, 20th and 21st of August and the ewes lost very little. The annual weeds in plot 5 apparently were providing additional feed in this paddock as the sheep made fair gains; whereas on plots 14 and 6, the losses were considerable. The crown buds on the alfalfa plants were just emerging at this time and it was thought that possibly the new growth consisting almost entirely of alfalfa was too succulent and laxative to permit the sheep to gain in weight at this time. The paddocks with the exception of plot 14 which was grazed straight through until October 1, were rested from September 1 until September 24, at which time 4 ewes were put on each plot. During the two-week period from September 24 to October 8 the sheep made good gains on the alfalfa-orchard and the alfalfa-smooth brome grass plots and the weedy alfalfa plot (No. 5). No. 6, however, which was a far better plot as regards stand of alfalfa, produced a considerable loss. This point was noticeable on other plots not in the present test and as a general observation during the fall grazing period alfalfa grass produced the best gains, poor alfalfa (weedy or grassy) produced fair gains, and in many cases, good clean stands of straight alfalfa produced losses. The sheep were turned off of plot 6 on October 8, but grazing was continued on plots 1, 3, and 5 until October 22. There was very little change in the weight of the sheep during this last period. In summarizing Table 1, the net gains and sheep days per acre for the different paddocks were as follows: alfalfa-orchard grass, 1,057 sheep days and 278 pounds gain; alfalfa and smooth brome grass, 1,039 sheep days and 387 pounds gain; plot 5 (alfalfa), 1,032 sheep days and 231 pounds gain; plot 6 (alfalfa), 854 sheep days and 176 pounds gain, and plot 14 (alfalfa), 1,120 sheep days and 214 pounds gain.

The relative gains made by ewes and their lambs on alfalfa, alfalfa-brome grass, and alfalfa-orchard grass pastures are illustrated in the graphs presented in Fig. 2. Under this particular system of grazing

management involving continuous grazing by a uniform number of sheep from spring to September 1, the pastures are undergrazed when growth is most rapid in May and June. The excess herbage thus accumulated is grazed off in July and August when plant growth is less rapid. It should be remembered, however, that summer growth of these crops when pastured is greater when the spring production has never been grazed off closer than 8 or 10 inches than had it been eaten to within 2 or 3 inches of the ground.

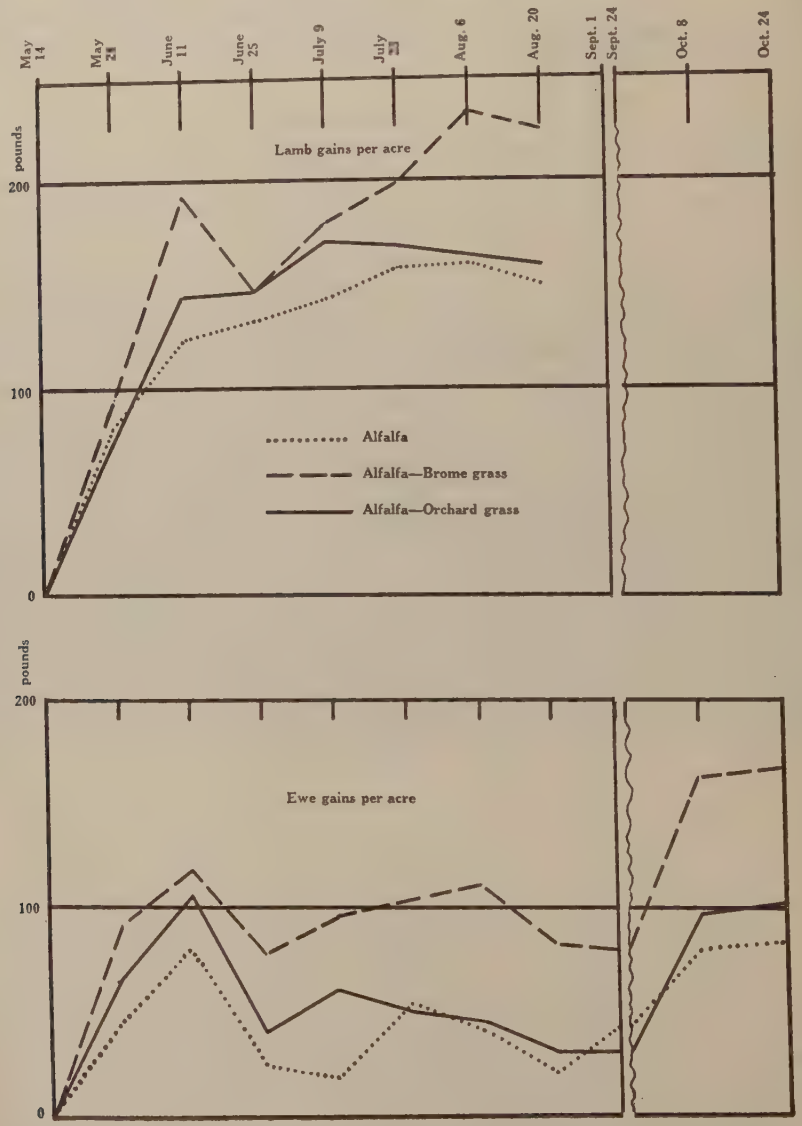

Fig. 2. Charts showing the relative bi-weekly gains made by ewes and lambs on straight alfalfa, alfalfa-brome grass and alfalfa-orchard grass pastures. W. K. Kellogg Farm trials, 1937.

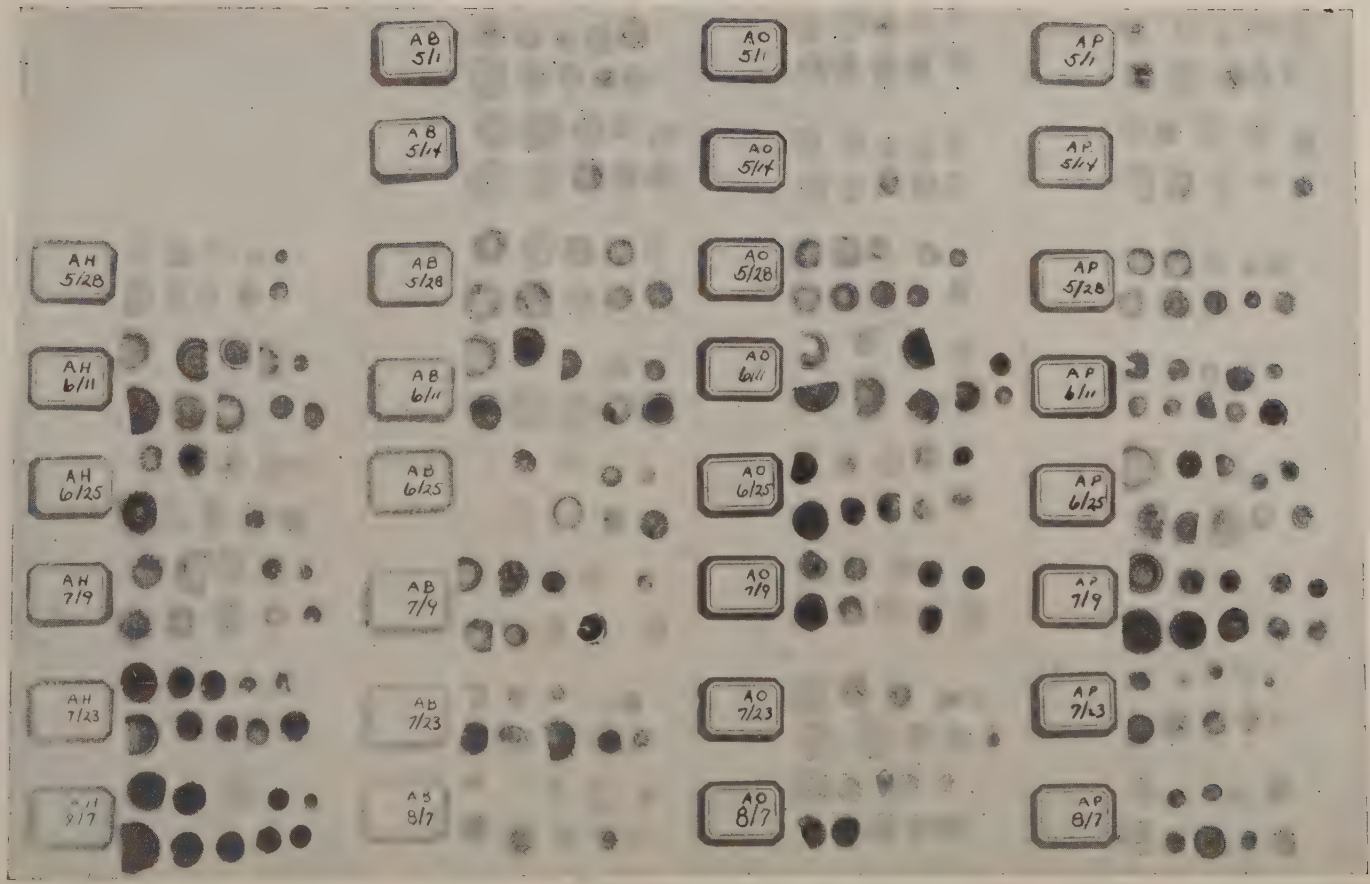

Fig. 3. Part 1—alfalfa roots showing accumulation of starch on the dates indicated. Alfalfa hay (A. H.), a pasture of alfalfa-brome grass mixture (A. B.), a pasture of alfalfa orchard grass mixture (A. O.), and alfalfa alone for pasture (A. P.).

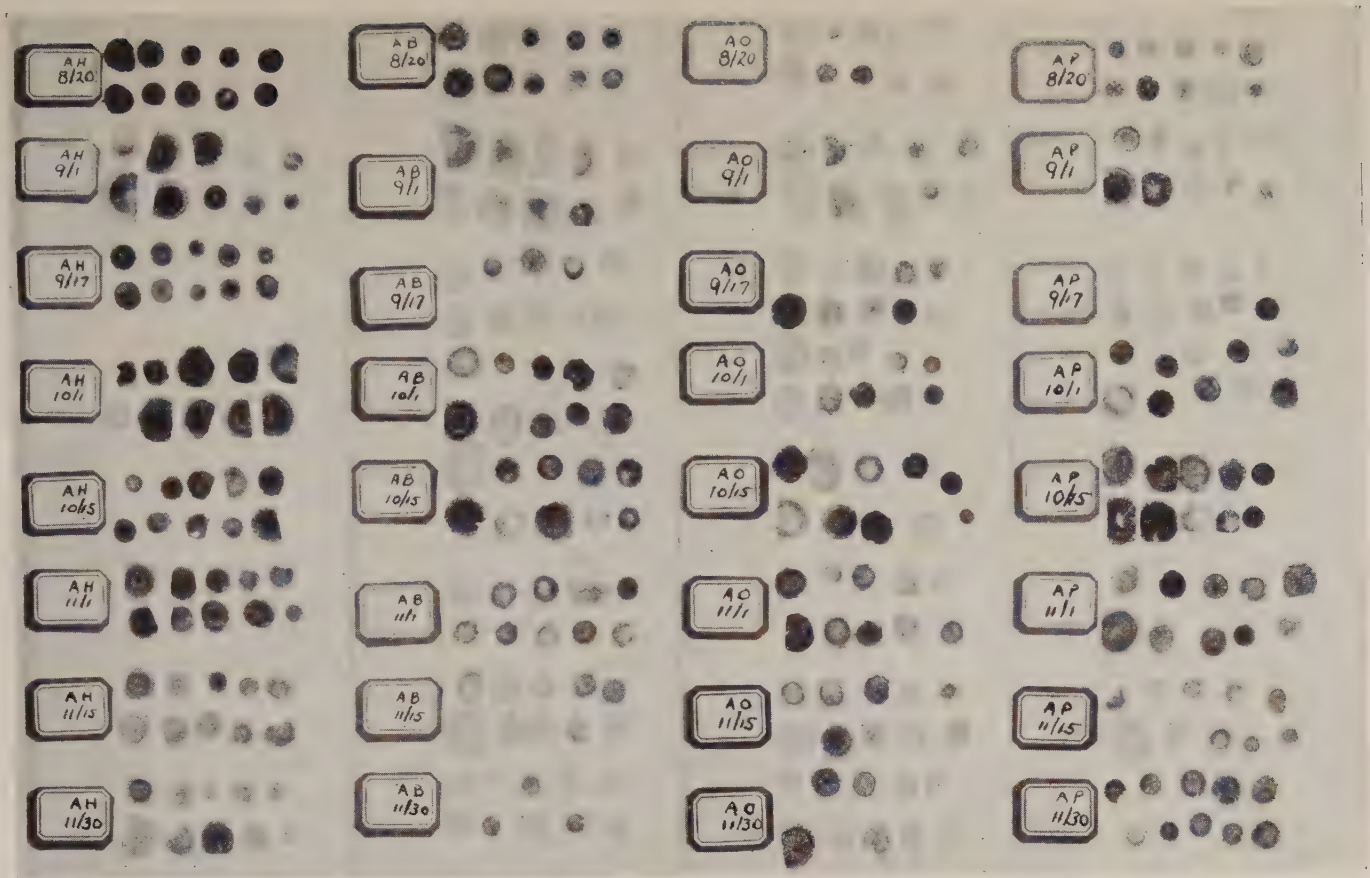

Fig. 3. Part 2—a continuation of Part 1, but at later collection dates.

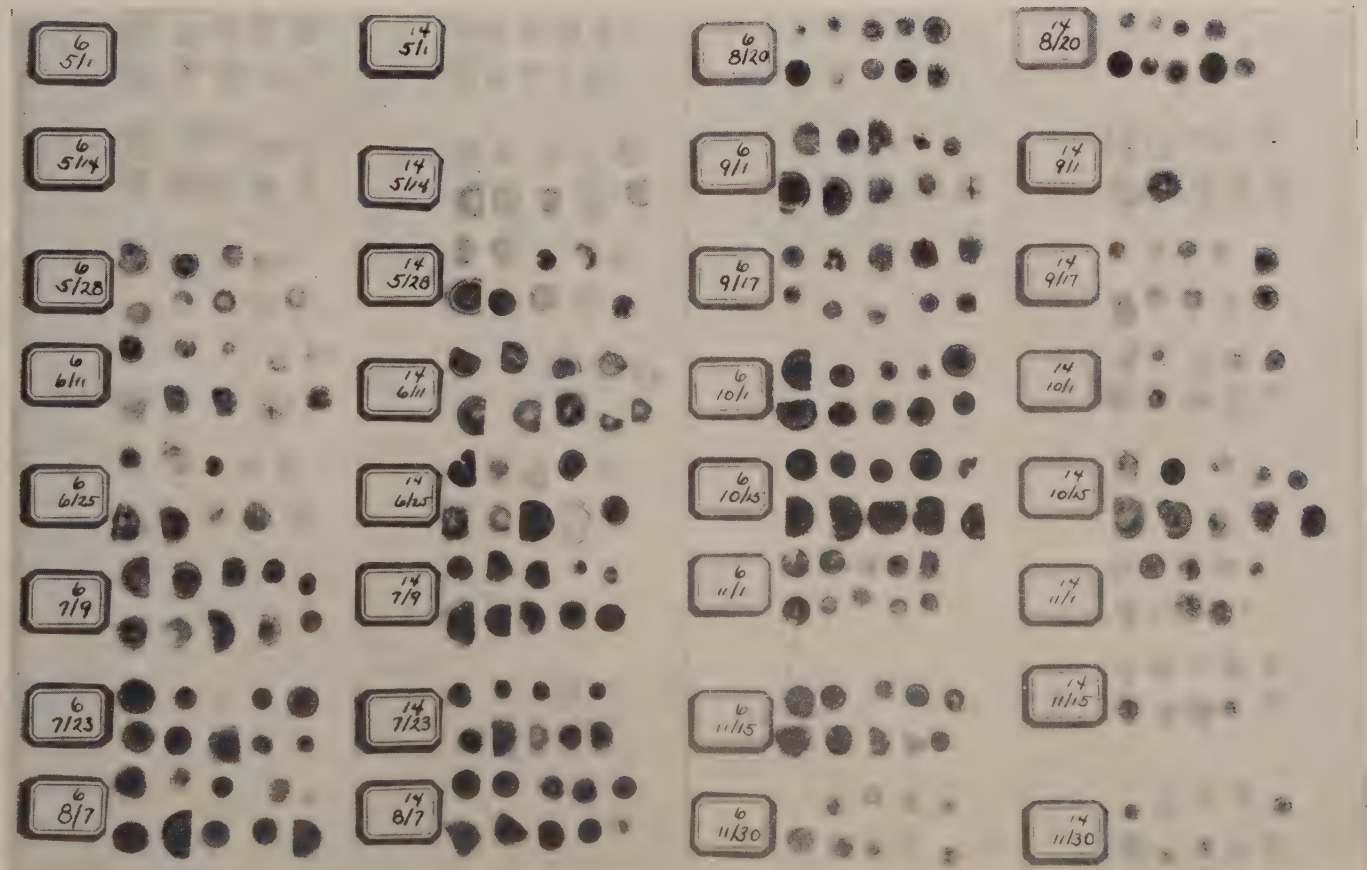

Fig. 4. Roots from plots 6 and 14 on collection dates as indicated. Note the difference in starch accumulation of the roots from the two plots from September 1 to November 30.

In all cases the early gains were most rapid with both ewes and lambs. In the case of the mature ewes this may have been due at least in part to relatively low weights as the ewes came through the winter, the average weight of the mature Shropshires used in these trials being 112 pounds May 14. Since the lambs likewise made most rapid gains during this period, the abundance of highly nutritious herbage during this period also was an important factor.

As the season progressed, the ewes on both straight alfalfa and alfalfa-orchard grass lost weight as compared with their condition June 11, but they were maintained in somewhat better condition than they were on May 14 when first turned onto these pastures. The ewes on the alfalfa-brome mixture maintained their maximum condition until both the alfalfa and brome grass began to run short near September 1.

The lambs made their best gains on the alfalfa-brome grass both individually and as a group. On the alfalfa-orchard grass, gains were negligible after July 9, evidently because all of the alfalfa had been consumed, the ewes had dried up and the accumulated growth of orchard grass was both unpalatable and lacking in nutritive value.

The total acre gains for the season made on the alfalfa-brome grass (224 pounds by the lambs plus 163 by the ewes) were very good. If valued at 9¢ a pound for the lambs and 4¢ for the ewes, the pasture gains amount to a gross value of $26.68. However, even on this pasture the lambs weighed only 68 pounds each by August 20. Whether another type of pasture management, such as providing lambs with second growth alfalfa-brome pasture, will induce still more rapid gains or whether supplementary grain feeding will be essential presents a problem for further study.

It was apparent that all pastures with the exception of plot 6 (straight alfalfa) had been grazed fairly hard and little feed was left. On plot 6 approximately 6-8 inches of growth remained when the sheep were taken off. Approximately 200 more sheep days pasture were obtained from 1, 2, 5, and 14 than from plot 6. Table 1 and the foregoing observations indicate the nature of the gains made by sheep on the various pastures. It remains to be shown how the pasture plants reacted to the sheep grazing.

It was thought possible that the alfalfa roots previously dug from the various pastures at two-week intervals from May 1 until December 1, might show differences in starch reserves when compared with alfalfa roots collected from a field which was cut for hay. The roots which had been pickled in alcohol were dehydrated, embedded in paraffin, sectioned on a microtome and 10 individual sections each from different roots, but collected from the same paddock, were placed as a sample on a glass slide. The roots were stained with Gram's iodine to detect starch storage. Photographs of the roots were taken, without enlargement and are shown in Figs. 2 and 3. Owing to the large number of individual roots and the differences between roots of a sample it was thought advisable to show all roots, though small, rather than attempt to select a representative one and enlarge it as was done in a previous bulletin (1). No roots were collected from the alfalfa hay plot on May 1 and May 14 because grazing did not begin on any of the plots until May 14 and the first two collections from any treatment were identical to the hay plots as they all had been treated similarly in 1936.

It will be noted from a study of Figs. 3 and 4 that the alfalfa did not have much reserve starch on either May 1 or 15, whereas on May 28, all roots show an increase in starch reserves. An occasional plant was grazed short in the pastures and shows up in the series of root sections as light in color because of an absence of starch owing generally to a lack of sufficient photosynthetic tissue for manufacture of reserve carbohydrates. By June 11 considerable variation is shown between the hay plot and the pasture plots. Considerably more starch was noticeable in the roots from the hay plot than from any of the pasture plots. The hay plot was cut June 18 and the roots collected on June 25 show a depletion in starch as compared with the roots collected two weeks earlier and previous to removal of the hay crop. On July 9 there was a slight building up of starch reserves in the roots of the alfalfa from this plot and on July 23 they appeared to be again well supplied with starch reserves. In the pasture plots it was apparent that alfalfa plants when in combination with grasses did not store starch reserves so readily as when the alfalfa was not in association with a grass. Brome grass grows faster in early spring and summer than does alfalfa; consequently, shading adds another factor tending to prevent carbohydrate manufacture by the alfalfa. Orchard grass does not start so fast in the spring as brome grass, is much more susceptible to frost injury than brome and consequently does not prevent starch accumulation in the alfalfa roots to such an extent as brome grass at this same period.

On July 7 the roots from the straight alfalfa pastures (plots 5, 6, and 14) showed considerable starch reserves; all from the alfalfa-brome grass plot had some accumulated starch, but at a lower level, while about a third of the roots from the orchard grass-alfalfa were completely depleted and the others fairly well supplied. On July 23 the starch reserves in the roots collected from the alfalfa-orchard grass plot were at a very low level in comparison with those collected from the straight alfalfa plots and alfalfa-smooth brome grass plots. It may be explained again that on this date, the sheep lost weight on the alfalfa-orchard grass plot and gained on all the others and also that the orchard grass was tall, abundant and mature while the alfalfa in with the orchard grass was grazed at less than one inch in height with the exception of occasional plants which the sheep failed to eat.

By August 20 the roots from the hay plot had accumulated a high level of starch reserves; the roots from the alfalfa-brome grass paddock were higher in starch accumulation than they were a month previous, those from the alfalfa-orchard grass plot showed no replenishment, while the roots from the straight alfalfa plots were in about the same condition as they were a month earlier. The hay plot was cut the second time on August 23. There was an apparent drop in starch reserves in the roots first collected following the cutting, but a rapid recovery up to October 1, after which there was a gradual depletion brought about largely by intermittent growth periods of short duration followed by killing freezes, preventing replenishment of starch in the roots. The roots from the alfalfa-grass mixture plots never reached so high an accumulation of starch as did those from the alfalfa hay or alfalfa pasture plots.

The roots from plots 6 and 14 show a significant difference from September 1, until the last collections were made. Plot 14 was grazed

during September and grazed short. Plot 6 was the lightest grazed of all plots and was not pastured from the first to the twenty-fourth of September. The roots from plot 14 were depleted far more by September 1 than those from plot 6, chiefly because bluegrass had taken over considerable areas in plot 14 and in late summer the alfalfa in this plot was over-grazed because of the non-productiveness of the bluegrass. As a result of the September grazing on plot 14, the plants had no period in which to grow and accumulate reserve starch in their roots before freezing weather. It was apparent that the roots from plot 6 had accumulated as much, if not more, starch than any of the other plots, even including the hay plot.

It was apparent from observations in the fall, when grazing was discontinued, that the alfalfa in all of the plots with the exception of plot 6 had been over-grazed and that serious winter-killing would result. In the spring of 1938, it was estimated that there had been almost a 100 per cent killing out of the alfalfa plants in the alfalfa-orchard grass plot, and only 25-30 per cent of the plants were left in the alfalfa-smooth brome plot and alfalfa plots 5 and 14. There was apparently no damage to the stand in plot 6.

Discussion

One of the difficult questions to answer in pasture management is that regarding carrying capacity, owing to the wide range of pasture types and response of pasture plants to environment. Again there are two problems in management: First, what happens to the livestock on a given pasture and, second, what happens to the plants in the pasture as a result of grazing. As a general consideration, most pastures in Michigan do not permit close grazing or attempting to graze off all of the forage which grows in a given period. A reserve supply of forage must be left on the pasture which may be utilized during the summer period when new growth is not sufficient for the grazing animal. Close grazing of alfalfa during the first part of May when the roots of the plants are completely lacking in reserve starch results in weakening, if not actually killing, of the plants. The plants would then be slow to recover and volume of growth would be lessened. However, it is possible to stock a pasture in such a manner that the livestock can remove only a small percentage of the growth, leaving a reserve supply of herbage which, if palatable and nutritious, will be eaten in advanced stages of maturity. In this way the plants are protected somewhat until reserves are built up and the animals likewise have a reserve supply of forage. Growth of alfalfa or smooth brome grass, the most drouth-resistant of our pasture plants in Michigan, is slowed up considerably during July and August, owing to hot, dry weather and it is during this period that the reserve supply of feed is eaten. Orchard grass was apparently unpalatable at late stages of growth in comparison to the alfalfa or brome grass and as a consequence, the alfalfa was grazed extremely heavy and resulted in a loss of the alfalfa stand, whereas the orchard grass thrived because of the differential grazing. Alfalfa, in order to survive in a mixture must be sown with a grass which is at least as palatable as, if not more palatable, than the alfalfa. On mixtures of alfalfa and smooth brome grass, livestock tend to graze from the top down and because of this

habit of grazing, it is possible to manage the pasture by removing the animals when grazing has reached a certain point or to so stock the pasture that a reserve supply of plant material is left at the end of the season.

It has been found (2, 3) that alfalfa and smooth brome grass both become weakened when cut at low levels continuously and at frequent intervals. The plants produce less new growth when cut at a level of one inch than when cut to a level of six inches. The photosynthetic tissue left below the height of cutting allows for recovery growth without a storage supply of starch and aids materially in keeping the reserve supply of starch in the roots at a high level during early fall, reducing the losses due to carbohydrate starvation and consequent winter-killing.

Although the pastures in this experiment were over-grazed with the exception of plot 6, a pasture of smooth brome grass and alfalfa has been used as a dairy pasture at the Kellog Farm for 3 years with very little loss of plant stands of either alfalfa or smooth brome grass. These pastures have been stocked with milking dairy cows for the last two years at one and one-half cows per acre from May 15 to September 1, at which time the cows have eaten all but 6-8 inches of the accumulated growth. In this manner of grazing the plants have sufficient top growth and time to replenish starch reserves in their roots previous to the advent of killing frosts.

In experiments with sheep over a 3-year period on native bluegrass pastures, it has been found that if the grazing was carried on, on a season long basis, the sheep rarely showed a net gain in excess of 100 pounds per acre and very frequently much less. During the year in which this experiment was conducted, for instance, a straight orchard grass pasture similarly fertilized produced a net gain for the season of only 59 pounds. The gains from alfalfa or alfalfa grass mixtures were far greater than this and usually pay well for the added expense and trouble in providing for this type of pasture.

The continued removal of practically all of the photosynthetic tissue of a plant, that is low in reserves, reacts unfavorably in weakening the plant, cutting down on the volume of new growth and also prevents replenishment of carbohydrate reserves in the plants. Consequently, it seems feasible to assume that a certain amount of leaf tissue should be left at all times or the complete removal of tissue should come at a time when the plants have sufficient reserve carbohydrates to initiate new growth. This new growth should not be removed completely until the reserves are replenished, and care must be exercised in grazing or cutting in the period approximately one month just prior to severe freezing weather.

Summary

In a study of ewe and lamb gains during the pasture season and a bi-weekly examination of alfalfa roots for starch reserves, the following observations were made:

1. Sheep gains were the largest during a period in the first part of the grazing season when the forage was succulent and pasture plants were producing new forage much faster than a reasonable number of animals could graze it.

2. Alfalfa roots were lowest in starch reserves during the period of most active growth in the spring. Starch reserves become depleted with close grazing or following a close cutting.
3. Alfalfa or a mixture of alfalfa and smooth brome grass returned far greater net gains per acre with sheep than did any of the native pasture plants when compared on a season-long grazing basis.
4. Alfalfa and orchard grass mixture was a poor mixture because of the difference in palatability of the two plants and resulted in over-grazing and consequent death of the alfalfa.
5. It was possible to judge the difference in palatability of the two grasses, orchard and smooth brome grass, by the condition of the alfalfa roots at a time when the orchard grass was unpalatable in relation to the brome grass.
6. Starch reserves in alfalfa roots previous to killing frosts were necessary to prevent carbohydrate starvation of the plants and subsequent winter-killing.
7. Alfalfa, grown by itself, stored starch in the roots much more readily than did alfalfa when grown in a mixture with grass.

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BASICOP AS A CHERRY SPRAY IN 1938

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Liquid lime sulphur used as a spray material for cherry leaf spot (*Coccomyces hiemalis*) again failed to control the disease in many Michigan cherry growing districts in 1938. Bordeaux mixture at higher concentrations, which has been used commercially as a spray for cherries, has given serious injury to foliage, dwarfing of fruit and stunting of trees, thus limiting its use under Michigan conditions. Although no other material proposed as a substitute for bordeaux mixture has been found to be its equal in fungicidal efficiency and adhesiveness, several of the new proprietary copper compounds have adequately controlled the disease and have caused distinctly less injury.

Observations and experiments during 1937 on Basicop, one of the proprietary copper compounds, indicated, as previously reported by

Cation and Robertson,[1] that concentrations of Basicop and lime at 3-8-100 satisfactorily controlled the disease and gave no perceptible injury. However, unsatisfactory results were obtained owing to foliage injury when Basicop was used alone or in combination with one pound of lime or less to 100 gallons of water. Concentrations of Basicop used as low as 1½-100 gave unsatisfactory control of the disease although these plats retained distinctly more foliage than did plats treated with liquid lime sulphur 2½-100. Dwarfing of the fruit was especially severe on those plats treated with bordeaux mixture 6-8-100. Continuations of these experiments and observations were made during 1938. This article is a preliminary report of the results obtained.

Experiments

The experimental plats of 1938 were again located at the Roach Orchards, Hart, Michigan. Montmorency cherry trees that were about nine years of age were used in these experiments. Conditions were very favorable for severe attacks of leaf spot in the vicinity although destruction of the old leaves by sheet erosion of the soil and early cultivation eliminated much of the initial inoculum in the experimental block. The trees in the experimental block were seriously weakened as a result of leaf spot infection the previous year. This afforded excellent opportunity to determine the injuriousness of the various treatments because trees with a lowered vitality are much more susceptible to spray injury than strongly growing and vigorous trees.

Only a few (Table 1) of the numerous experimental treatments will be discussed in this article. Each plat in the experimental block included 9-12 trees. Those plats with a four-spray program received the petal-fall application on May 10, the two-weeks application on May 27, the four-weeks spray on June 16, and the after-harvest spray on August 6.

Table 1. Some spray materials and concentrations used in experiments at Roach Orchards, Hart, Mich., 1938.*

Basicop—lime	2–4 –100
Basicop—lime	3–6 –100
Basicop—lime	3–8 –100
Basicop—zinc sulphate—lime	2– 1–1½–100
Basicop—zinc sulphate—lime	2– ¾–4 –100
Bordeaux mixture	6–8 –100
Cupro K	3 –100
Liquid lime sulphur	2½–100

*Lead arsenate was included in the two-weeks spray and four-weeks spray of all treatments.

Although the period of full-bloom was exceptionally early (May 2-9), the first leaf spot lesions were not noted until May 31 on the untreated control trees or in other orchards examined in Oceana County. Observations and microscopical examinations indicated that the first primary infections occurred on May 20, 25 and 27. The rainfall in inches on these dates was 1.49, 0.10 and 0.93, respectively, while the mean temperatures were 55, 51, and 66 degrees F. Numerous secondary infections began to occur about June 1-2 resulting in the first

[1]Cation and Robertson. Basicop as a cherry spray. Mich. Agr. Exp. Sta. Quart. Bul. **20**: 199-210. 1938.

yellowing and defoliation on June 12. An abnormal amount of rainfall throughout the latter part of May and during June, combined with comparatively warm temperatures, furnished ideal conditions for epidemic development of the disease. Successive defoliations occurred at approximately 10-day intervals during moist periods throughout the remainder of the season.

Results

Three untreated control trees in different sections of the experimental block were maintained throughout the entire season. The first infections of the season were noted on those trees, but, despite this, no defoliation due to leaf spot occurred on the trees until the harvest period (July 20-27). Defoliation was complete the latter part of August. The fact that the untreated trees were lightly infected during the pre-harvest period indicates that this orchard had a much less acute leaf spot control problem than many orchards in the immediate vicinity.

The plat treated with liquid lime sulphur received the four-spray schedule at a concentration of 2½-100. Although the foliage had many scattered infections throughout the pre-harvest period, the first serious wave of yellowing and defoliation due to leaf spot did not occur until August 5-6, just prior to the after-harvest application. The trees in this plat were defoliated completely before September 1.

There was no defoliation due to leaf spot in the experimental plats treated with bordeaux mixture at a concentration of 6-8-100. Defoliation caused by spray injury, however, was noted on these plats shortly after the harvest period and lasted until the after-harvest spray was applied. Slight amounts of injury to the foliage were also noted the latter part of September. Plats receiving a three-spray program of bordeaux mixture showed much more spray injury than did plats receiving the four-spray treatment.

Cupro K 3-100 used in a four-spray program controlled leaf spot satisfactorily. Foliage injury was first noted on this plat early in the season and was followed by several succeeding defoliations at later dates.

Results obtained in plats treated with Basicop-lime combinations closely paralleled those obtained in the 1937 experiments (1). Three-pound concentrations of Basicop in combination with 6 to 8 pounds of lime in 100 gallons of water gave adequate and satisfactory control of the disease. No noticeable injury occurred on the plats treated with Basicop 3-6-100. A slight amount of injury occurred early in the season in the plat treated with Basicop-lime 3-8-100 although no further injury was noted. The plat receiving a four-spray treatment of Basicop 2-4-100 had adequate control of leaf spot but had a slight amount of foliage injury.

Leaf spot infection was held to a minimum in plats treated with concentrations of Basicop-zinc sulphate-lime at 2-¾-4-100 and 2-1-1½-100 and there was no spray injury to the foliage. A small amount of leaf spot was noted during final data collections, October 8, on the plat which received the Basicop-zinc sulphate-lime 2-¾-4-100 spray treatment. The use of zinc sulphate in these experiments effectively prevented spray injury. These preliminary results on zinc sulphate as a preventative of injury in cherry sprays offer considerable promise and merit further investigation.

Fig. 1. Typical foliage on tree sprayed with Basicop-lime 3-6-100. Experimental plat, Roach Orchards, Hart, Mich., Oct. 8, 1938.

Reduction of fruit size caused by spray injury was not marked during 1938. The abnormally wet season tended to prevent fruit dwarfing. However, a slight reduction of fruit size occurred in certain plats treated with bordeaux mixture. Basicop, with lime or with zinc sulphate-lime, and Cupro K in comparison with liquid lime sulphur treatments caused no perceptible dwarfing of the fruit.

Summary

Results of spraying tests conducted in 1938 to compare the effects of certain spray materials as cherry sprays were essentially similar to those obtained in the experiments in 1937.

Liquid lime sulphur used at 2½-100 and following the recommended four-spray program did not give adequate control of the disease in either 1937 or 1938.

The tendency to dwarf the fruit and to injure the foliage in these experiments again indicates that a four-spray program of bordeaux mixture at 6-8-100 is unsatisfactory as a spray for cherries in Michigan.

Cupro K gave good control of leaf spot but gave severe injury to the foliage.

Basicop-lime at concentrations of 3-8-100 or 3-6-100 has given satisfactory control of the disease and little perceptible injury. Basicop used without lime or zinc sulphate-lime has been unsatisfactory because it consistently caused injury to the foliage. When used in concentra-

tions of 1½-100 Basicop has not proved adequate for the control of cherry leaf spot.

A four-spray program of Basicop-zinc sulphate-lime at 2-1-1½-100 shows definite promise as a spray for cherries. This combination in limited experiments gave adequate control of the disease and no foliage injury.

TESTS OF NEW DUST AND LIQUID FUNGICIDES IN 1938 FOR CONTROL OF CELERY LEAF BLIGHTS*

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The leaf blight diseases are perennially a serious menace to the profitable culture of celery in Michigan. With control of Fusarium yellows achieved by the development of resistant varieties, the chief problems confronting growers is control of the leaf diseases that take such a heavy toll of profits. That the problem is an acute one can be doubted by no one who has seen the effects of leaf blights in seasons like those of 1937 and 1938. The 1938 outbreak was an unusually severe one, striking destructively in the midsummer and late crops of celery, especially in the districts of intensive culture. It is doubtful if a more serious epidemic has swept over those areas in the last two decades, leaving in its wake crop failures for hundreds of growers. The effects of these diseases were quickly reflected in market conditions during August and September when prices paid to growers reached the lowest level in many years, and a more stagnant condition of the markets has probably not occurred previously. While the 1938 low prices cannot be attributed solely to the effects of leaf diseases, flooding of markets in August with blighted, low-grade celery quickly resulted in a curtailed consumer demand and a depression of prices far below those received earlier in the season. Many plantings were so badly blighted that the yields of marketable celery were insufficient to defray the costs of production. Large quantities of this low-grade celery were dumped on the markets at prices which lowered the levels established for celery of good quality.

That these diseases can be controlled well enough to prevent such losses was demonstrated in the results of dusting and spraying experiments conducted in Kalamazoo and Van Buren counties in 1935, 1936, and 1937 (2, 3, 4). Similar results have not been obtained by growers, however, and their efforts were especially unfruitful in 1938, when dusting and spraying often failed to provide a satisfactory degree of protection against leaf diseases. Many growers question the effectiveness of the fungicides commonly used to control these diseases and are constantly seeking more efficacious materials in new fungicides used successfully on other crops.

*A portion of the cost of conducting these tests was defrayed from funds provided by the Sherwin-Williams Co., Cleveland, Ohio.

The 1937 experiments with both dust and liquid fungicides provided information for comparing the fungicidal value in that season of various new materials. As explained previously (4), there is a definite need for the development of a substitute for the copper sulphate-lime dust fungicides since these dusts contain large excesses of hydrated lime. The use of such dusts year after year in districts such as Kalamazoo has resulted in creating soil conditions on many farms increasingly less favorable for the production of celery. A major objective of these experiments is the development of an efficient fungicidal dust that contains no lime or one in which the lime is not sufficient to shift soil reactions significantly when used for a period of years. The beneficial effects of sulphur were noted in the 1937 tests, and it was suggested that if it could be combined with copper compounds such a combination might be a good substitute for the copper sulphate-lime mixtures. This report is on the results obtained with such dust combinations and others not previously tested as well as on the comparative efficiencies of bordeaux mixture and some copper fungicides of low solubility.

Dusting Experiments at Comstock

Materials and Methods—In the 1937 experiments sulphur alone was not an effective fungicide for the control of celery leaf blights, but there were obvious beneficial effects from its use. The copper sulphate-lime dusts have usually given superior disease control; nevertheless, some of the newer copper materials are being used by growers in a limited way. The inclusion of talc and other inert fillers in these new dusts is a distinct advantage in most sections where the copper sulphate-lime combinations have been used for many years. It seemed, therefore, that if these low solubility copper compounds could be combined with sulphur and inert fillers, such a dust would eliminate the objectionable features of the combinations containing lime. A purely empirical formula was submitted to three manufacturers of copper fungicides with the request that they prepare dusts for use on celery to contain the following ingredients in these proportions:

Copper 7 per cent
Superfine dusting sulphur 30 per cent
Talc filler to make 100 lbs.

It was also suggested that dusts of similar composition be prepared with the addition of materials to increase the adhesive properties.

Dusts of the following composition were submitted for these tests:

Cuprocide dust No. 1*
Cuprocide (92 per cent copper) 7 lbs.
Sulphur 30 lbs.
Talc 63 lbs.

Cuprocide dust No. 2*
Cuprocide 7 lbs.
Sulphur 30 lbs.
Dry Aresket sticker 1⅔ oz.
Talc 63 lbs.

*Röhm and Haas, Philadelphia, Pa.

Bordow dust No. 1**
Bordow (40 per cent copper) 18 lbs.
Mike dusting sulphur 31 lbs.
Talc 51 lbs.

Bordow dust No. 2**
Bordow 18 lbs.
Mike dusting sulphur 31 lbs.
Bentonite 10 lbs.
Talc 41 lbs.

Basicop dust No. 1***
Basicop (50-52 per cent copper) 14 lbs.
Talc 86 lbs.

Basicop dust No. 2***
Basicop 14 lbs.
Sulphur 30 lbs.
Santomerse sticker ¼ lb.
Talc 55¾ lbs.

In addition to the commercially mixed dusts listed, the following were prepared locally:

Standard 20-80
Monohydrated copper sulphate (33 per cent copper) 20 lbs.
Hydrated spray lime 80 lbs.

20-30-50
Monohydrated copper sulphate 20 lbs.
Hydrated spray lime 30 lbs.
Talc 50 lbs.

The 20-30-50 modification of the standard 20-80 mixture was prepared with the object of retaining the effective fungicidal properties of the copper sulphate-lime mixture with the elimination of the excess of hydrated lime.

The dusting experiments were conducted on the farms of L. Knott and Lewis Wanders, Comstock, Mich. Three sets of plats were established in spaced plantings of celery for marketing in August and September. It is these plantings that are most seriously affected with leaf blights. The earliest planting, which is ready for market in late June and July, usually is not dusted because it matures early enough to escape damage from leaf diseases. Weather conditions, however, were unusually favorable for the development of leaf blights in June, and disease in the early planted celery reduced yields measurably in undusted fields. It was the exceptional development of leaf blights in the early plantings that made their control so much more difficult in the later settings. Both early blight *(Cercopora apii)* and late blight, *(Septoria apii-graveolentis)* were observed June 6 in the early plantings, and by July 1 infections were general on the bottom leaves.

On the Knott farm Basicop No. 1, Basicop No. 2, Cuprocide No. 1, Copper sulphate-lime 20-80 and the copper sulphate-lime talc 20-30-50 dusts were compared. These same dusts and Bordow No. 1 were used in the plats on the Wander farm. The treatments were replicated four times in plats consisting of 5 rows 2 rods long. The dusts were applied with hand-operated dusters at rates as nearly equal as possible,

**Dow Chemical Co., Midland, Mich.
***The Sherwin-Williams Co., Cleveland, Ohio.

but owing to differences in density and other physical properties, it was not possible to adjust the duster to discharge equivalent quantities. Thorough coverage is essential to good control and since physical properties determine to some degree the dispersion of the dust particles, those dusts with superior flowing qualities covered the foliage more thoroughly. The Cuprocide dusts were superior in flowing qualities and the uniform discharge and maximum dispersion of the particles resulted in a degree of coverage not achieved with any dusts used previously. These dusts possessed ideal properties for application in hand-operated dusters of the type used in these experiments. Basicop dust No. 2, was difficult to apply evenly owing to some property not yet determined. The discharge from the duster was irregular and the coverage of the foliage was very uneven. The 20-80 copper sulphate-lime dust did not possess good flowing qualities and the modified 20-30-50 showed no improvement in this respect.

Records—The comparative effectiveness of the dusts was determined from counts of the number of blight lesions on leaves of approximately the same age. Just before the crop was harvested a leaf from the bottom of 10 plants selected at random in every plat was removed and the number of spots counted on the two opposite leaflets just below the apex. The area of each leaflet was then measured by means of the photoelectric device developed by Hibbard, Grigsby, and Keck (1). Since each treatment was replicated four times, this entailed the taking of records of 80 leaflets for each dust used. From these data, the number of blight infections per leaflet and per unit area (cm) of the surface could be calculated. Since both surfaces of the leaflets are exposed to infection, the total surface area was twice that obtained from the reading on the photoelectric device. Because of the wide variation in the size of the leaflets from the various plats, the number of blight spots per unit area of leaflet surface gives a more accurate comparison of the effectiveness of the dusts than the number per leaflet. In general, the sizes of the leaflets were proportional to the degree of blight control. The presence of numerous infections checked the development of the leaflets and prevented their attaining normal size.

Yields records were taken at time of harvest and consisted of the net weights of the trimmed plants before they were packed into crates. The weight records in the Wanders plantings are much lower than those in the Knott plats because of injury to the plants from excessive wetness of the soil in August after the Knott plats had been harvested.

No predetermination of the number of applications required to control leaf blights can be made. Weather conditions determine not only the number of applications but also the time the dust must be applied to be most effective. The dusting was usually done shortly after daybreak or at dusk to take advantage of lulls in breezes, which, in summer, blow constantly over the marshes from about 8 a. m. to 8 p. m. Another advantage of early morning or evening dusting is the presence of moisture on the leaves from dews.

Results—In Table 1 are summarized the data on comparative blight control and yields from the plats on both the Knott and Wanders farms.

Table 1. Comparative blight control and yields in celery plats dusted with various fungicides, Comstock, Mich., 1938. Data from plats consisting of 5 rows, 2 rods long, replicated 4 times.

KNOTT FARM

Treatment	No. of Blight Spots on 80 Leaflets	Average No. Per Leaflet	Sum of Surface Areas of Leaflets, cm2	Average No. of Spots Per cm2	Yield, Net Weight Pounds	Per cent Increase in Yield Over Undusted
Cuprocide No. 1	615	7.7	4,032	0.15	1,086	57
20-80	652	8.1	3,606	0.18	1,120	62
Basicop No. 1	742	9.2	3,436	0.22	1,145	64
Basicop No. 2	995	12.4	3,698	0.27	1,078	56
Undusted	1,712	21.4	3,316	0.52	691	

Applications June 20, 24, 30, July 5, 9, 13, 16, 18, 29. Harvest August 5.

WANDERS FARM

Cuprocide No. 1	516	6.4	4,146	0.12	413	32
Bordow No. 1	822	10.3	3,850	0.22	357	10
Basicop No. 2	970	12.1	3,474	0.28	361	15
20-80	1,142	14.2	3,482	0.33	330	5
20-30-50	1,137	14.2	3,340	0.34	340	8
Undusted	2,967	37.0	3,118	0.96	313	

Applications June 20, 24, 30, July 5, 9, 13, 16, 18, 23, 25, 26, Aug. 8, 11, 18, 22, 26. Harvest Sept. 1.

On the Knott farm satisfactory control of leaf blights was obtained with all the dusts used. The control was more satisfactory than the records show since most of the infections were due to the late blight fungus and the spots were small and so few they did little damage to the plant. In the undusted plats, however, the development of both early and late blights was extensive enough to cause very noticeable injury to the plants. The records show that control of leaf diseases with all the dusts resulted in very profitable increases in yields.

In no previous season since these experiments were started has any dust excelled the 20-80 copper sulphate-lime combination in fungicidal efficiency. Cuprocide No. 1 surpassed all others in effectiveness in the plats on the Knott farm and as will be seen later this superiority was also maintained in the later plantings. The 20-80 dust was slightly more effective than Basicop No. 1 which in turn gave better control than Basicop No. 2. Examination of the plants just before harvest revealed no perceptible injury from any dust. While the degree of blight control achieved with each of the dusts tested was satisfactory in this medium-early crop, leaf blights had not yet reached the peak of their destructiveness and the probable effectiveness of such dusts during periods of maximum spore dispersion later in the season, could not be predicted from the results in this planting.

The plats on the Wanders farm were not harvested until almost four weeks later. During this interim the weather was extremely favorable for leaf blights. There was considerable injury to the plants from heavy rains and flooding of the plats. The leaves became chlorotic and the plants were stunted and failed to respond to ordinary cultural methods. In this condition they appeared to be much more susceptible to infec-

tion and blight spread more rapidly. The dusts seemed to be much less effective than earlier when the plants were growing at a normal rate.

In these plats three dusts of similar composition were compared with the 20-80 and its 20-30-50 modification. Basicop No. 2, Bordow No. 1 and Cuprocide No. 1 were composed of copper materials of low solubility, sulphur, and talc. Basicop No. 2 also contained a sticking agent. Each dust contained the same quantities of copper and sulphur with a variation only in the talc content. It was expected that these three dusts would protect the plants equally well because of similarity of compositions. Each of them controlled leaf blights better than did the 20-80 or the 20-30-50, but Cuprocide No. 1 was again the most effective. Significant differences are apparent in the degree of control obtained with this dust when compared with Bordow No. 1, the second most effective one in the series. The 20-80 ranked lower than any of the dusts containing copper, sulphur, and talc and these results further strengthen the belief that these materials can be combined to form a dust fungicide superior to the copper sulphate-lime mixtures. No injury from the dusts was apparent, but this could not be determined with certainty since the plants were somewhat dwarfed and chlorotic because of soil conditions.

The greater effectiveness of Cuprocide dust No. 1 may have been correlated with better coverage of the plants owing to its smoother flowing qualities. There is some evidence for this possibility in the results of the chemical analyses for residual copper on the leaves (Table 5). The results obtained in this test were essentially similar to those from the earlier planting on the Knott farm. Their consistency under different sets of conditions when, in one case, leaf blights were comparatively easy and, in the other, difficult to control, indicates that this particular combination of materials possesses superior qualities as a fungicide for celery blight control.

The 20-80 and the 20-30-50 dusts provided about the same degree of protection which indicates that reducing the quantity of lime from 80 to 30 pounds in the 20-80 mixture did not impair the fungicidal efficiency of the copper. Since the larger quantity of lime is undesirable the inclusion of the talc as a substitute is a distinct advantage. Neither the 20-80 nor the 20-30-50 mixture has physical properties that characterizes a good dust fungicide. They do not flow smoothly or evenly from the duster and do not store well, even for short intervals. Unless used very soon after mixing or stored in moisture-proof containers they absorb water and become lumpy. Since it seems probable that some combination of insoluble copper compound, sulphur and talc, such as Cuprocide No. 1, can be prepared that will be equally effective and possess more desirable physical properties, other modifications of the 20-80 dust need not be prepared.

The low yields in these plats as compared with those on the Knott farm were due to the stunted condition of the plants because of wet soil. The comparative yields are not, therefore, so good an index of the relative fungicidal values of the dusts as they would be under more favorable growing conditions. It will be noted that the increases in yield are not always proportional to blight control. Though the plats were replicated four times slight variations in elevation in various parts of the field had a differential effect on the growth of the plants following the heavy rains in August.

Influence of Stickers on the Effectiveness of Dusts

Better control of leaf blights has generally been obtained with bordeaux mixture than with the copper sulphate-lime dusts. This has been attributed to the superior adhesive qualities of the liquid fungicide. The dust combinations are apparently quickly removed by rains so that more frequent applications are required to maintain protection. A series of plats were laid out on the Wanders farm to test the comparative effectiveness of the copper-sulphur-talc dusts with and without stickers. A sticking agent was added by the manufacturer to the Bordow, Cuprocide, and Basicop dusts, and they were compared with those containing no adhesive. Basicop No. 1 contained no sulphur, but it was used in this test to complete the series. The composition of each dust can be determined by referring to the list of materials (page 296). Only three replications could be made of each treatment owing to the number of dusts used and the arrangement of the rows. The summarized data from these plats are listed in Table 2.

Table 2. Tests of fungicidal dusts prepared with and without sticking agents for control of celery leaf blights, Wanders farm, Comstock, Mich., 1938. Plats 3 rows wide 1¾ rods long, replicated 3 times.

Treatment	Total No. of Infections on 60 Leaflets	Average No. Per Leaflet	Sum of Surface Areas of Leaflets, cm2	Average No. of Infections Per cm2	Yield, Net Weight Pounds
Cuprocide No. 1	433	7.2	3,080	0.14	220
*Cuprocide No. 2	657	10.9	2,988	0.22	200
Bordow No. 1	774	12.9	2,774	0.29	213
*Bordow No. 2	816	13.6	2,612	0.36	206
*Basicop No. 2	761	12.6	2,482	0.31	171
Basicop No. 1	935	15.7	2,612	0.36	182
Undusted	2,690	44.8	2,190	1.23	162

Applications: July 19, 23, 25, 27, Aug. 2, 8, 11, 18, 24, Sept. 2. Harvest Sept. 9.
*Contains sticker.

Injury from excessive wetness of the soil was very pronounced in these plats and is reflected in the low yields. Cuprocide No. 1 again was the most effective dust and its efficiency was not increased by the addition of Aresket sticker. The differences are great enough in the degree of control achieved with Cuprocide No. 1 and Cuprocide No. 2 to indicate that the addition of Aresket sticker decreased the fungicidal value of the dust. Adding Bentonite to Bordow dust No. 1 had no effect in shifting the efficiency of this dust in either direction. Basicop No. 2 gave slightly better control of leaf blights than No. 1, but the difference is slight. The increased fungicidal value of the No. 2 dust might be due to its sulphur content rather than to Santomerse sticker, although Basicop No. 1 gave better control in the earlier test on the Knott farm. Surveying the results in the entire series, it seems apparent that the effectiveness of a dust is determined by factors other than adhesiveness. That the addition of these sticking agents did increase the adhesiveness of each dust, is shown by the comparative quantities of copper remaining on the leaves at harvest time (Table 5).

Liquid Fungicides For Blight Control

The spraying tests were conducted on the farm of John DeFeyter and Marin Dees at Decatur. Plats were laid out in a field on which celery had been grown for several consecutive years, and in a vicinity where blight had caused serious damage to the 1937 crop. The crop sprayed was a late planting of tall strain Golden Self Blanching, and the transplanting was not completed until July 4. The rows were 55 rods long and spaced 42 inches. When this field was selected for the experimental work the drainage appeared to be adequate and the growers stated that Fusarium yellows had not affected the 1937 crop. In August, however, there was some damage from excessive wetness of the soil in some sections of the field, and during the warm and dry weather of July and early August Fusarium yellows caused dwarfing of plants in restricted areas. The materials tested and concentrations used are shown in Table 3.

Table 3. Concentrations of materials to make 100 gallons of spray for the control of celery leaf blights, Dees and DeFeyter farm, Decatur, Mich., 1938.

Basicop 4 pounds, Sherwin-Williams 81-S sticker 1 pint.
Basicop 4 pounds, lime 6 pounds, 81-S sticker 1 pint.
Basicop 4 pounds, lime 6 pounds, zinc sulphate 1 pound.
Basicop 4 pounds, lime 6 pounds, wettable sulphur 4 pounds.
Bordeaux 8-12-100 (Copper sulphate 8 pounds, lime 12 pounds.)
Bordeaux 8-6-100 (Copper sulphate 8 pounds, lime 6 pounds).
Copper A (Copper oxychloride, 45% Cu.) 4½ pounds, Grasselli sticker ½ pint.
Cuprocide 54 (Red Copper oxide, 48% Cu., and sticker) 4 pounds.

The rainfall from July 1 to August 15 was very light and blight infections were not numerous until after frequent and heavy showers occurred subsequently. From August 15 to September 15 showers were spaced favorably for the rapid spread and development of both early and late blights and by September 1 the plants in the unsprayed rows were heavily infected. At the time the last two applications were made the bottom leaves on the unsprayed plants were dead and damage was severe in these plats. After September 15 no rain fell until after the plats were harvested, and no late infections occurred even in the unsprayed rows.

The sprays were applied with a Bean power sprayer operated at 300-350 pounds pressure. For the late applications, when the plants were largest, a minimum pressure of 400 pounds would have given a much more effective coverage.

The yield records are based on data taken in a selected portion of the field where no damage occurred from water or from Fusarium yellows. A section crosswise of the plots was chosen, and the celery harvested and packed into ⅔-crates. Each plat of 2 rows 55 rods long was approximately 1/7 of an acre and the yield records were taken from ⅛ of this area in each plat. By multiplying the actual yields obtained from these small plats by 56 the yields per acre were obtained. Only by this method of sampling could a fair comparison of the effects of the fungicides on yield be obtained. Damage from water and Fusarium yellows was confined to irregular areas and the records had to be taken from a portion of the field where such damage had not occurred.

Table 4. Comparative effectiveness of liquid fungicides in the control of celery leaf blights, Dees and DeFeyter farm, Decatur, Mich., 1938. Data from duplicate plats 2 rows wide and 55 rods long.

Treatment	Total No. of Blight Infections on 100 Leaflets	Average No. Per Leaflet	Sum of Leaflet Surface Areas cm2	Average No. of Infections Per cm2 of Surface Area	Yield: 2/3-Crates Per Acre		Increase in Yield Over Unsprayed Per cent
					Jumbo Grade	Medium and Small Grades	
Bordeaux 8-12-100	138	1.38	4,892	0.03	196	210	81
Bordeaux 8-6-100	190	1.90	5,066	0.04	196	210	81
Copper A	434	4.34	4,746	0.09	140	196	50
Basicop-sticker	917	9.17	4,718	0.19	—	280*	25
Cuprocide 54	1,143	11.43	5,284	0.21	168	210	69
Basicop-lime-sulphur	1,088	10.88	4,586	0.23	112	252	62
Basicop-lime-sticker	1,315	13.10	4,622	0.28	140	224	62
Basicop-lime-zinc	1,301	13.01	4,188	0.31	56	252	37
Unsprayed	7,689	76.89	4,440	1.73	0	224†	

Applications: July 15, 19, 24, 29, Aug. 1, 15, 18, 22, 29, Sept. 3, 12, 16, 21.
*Did not receive applications of July 15 and 19. Low yields due partly to water injury. Harvested without grading; includes jumbo, medium and small sizes.
†Small sizes only.

Results—The summarized data from these plats are shown in Table 4. The bordeaux sprays controlled leaf blights so much more effectively and left the foliage in such good condition that there could be no doubt of the superiority of these mixtures over the rest of the materials used in this test. The better color and freedom from disease of the leaves in the bordeaux plats became more and more noticeable as the season advanced and leaf blights reached the peak of distructiveness. A cursory examination of the plants gave the impression of complete control of leaf blights by the bordeaux sprays. One of the bordeaux plats was immediately adjacent to one unsprayed and late in the season the leaves of plants in the adjoining rows were almost in contact. The sprayed plants were thus subjected during rains to heavy inoculations with spores of *Septoria apii-graveolentis* splashing from the badly blighted leaves in the unsprayed row. Despite such favorable conditions for infection, bordeaux mixture protected the leaves far better than did other fungicides in the rows where the plants were not exposed to such heavy inoculation. The striking contrast between the appearance of the unsprayed plants and the adjacent ones protected with bordeaux proved of special interest and a source of much comment from growers who visited the plats in late September.

Of the other copper materials, Grasselli Copper A was the most effective in blight control. Both early and late blight were controlled satisfactorily by this fungicide and it would be an acceptable substitute for bordeaux were it not for its toxic effect on the plants. This will be referred to later.

Of the four Basicop sprays, the one consisting of Basicop and sticker was the most effective. Lime, added to counteract any possible toxic effect of copper on the celery plant, not only failed to prevent this type of injury, but also decreased the effectiveness of the fungicide. The Basicop-lime-zinc and Basicop-lime-sulphur sprays were not effective combinations and controlled leaf blights much less satisfactorily than

the Basicop-sticker combinations. Cuprocide 54 was about equal to the Basicop-sticker spray in effectiveness.

The yield records show that the bordeaux plats were most productive and that the best market grades of celery came from the rows sprayed with those fungicides. All of the plants from the unsprayed rows were of the lowest grade (Hearts) and were marketed with difficulty even at very nominal prices. In contrast, almost half of the plants from the bordeaux plats went into the jumbo grade which commanded the highest prices. Taking the total number of crates as a basis for comparing yields, the bordeaux plats produced 81 per cent more than did the unsprayed rows; Cuprocide 54 ranked next with a 69-per cent increase and the Basicop-lime-sticker, Basicop-lime-sulphur combinations increased the yields in those plats by 62 per cent. Copper A plats yielded 50 per cent more than did the unsprayed rows and the Basicop-lime-zinc plats produced 37 per cent more crates than the check plats. The Basicop-sticker plats were the lowest yielding ones in this series, but this cannot be attributed to a low fungicidal index of the spray, since this combination controlled leaf blights better than the other Basicop mixtures. These plats were not included in the original plan of the experiment and did not receive the first two applications. In addition, they were in a portion of the field less favorably located than others in the Basicop series and were damaged some by water. Under more favorable conditions yields in these plats would have been higher, owing to the better blight control achieved with this spray. A factor contributing to the smaller yields in all the plats sprayed with the copper materials of low solubility was the toxic effects of these sprays on the celery plant.

Copper Injury—During July and August no pronounced differences in color of the foliage could be detected on the plants in the various plats. In September, however, with the advent of lower mean temperatures, the plants sprayed with the low solubility copper materials showed evidence of injury in a yellowing of the leaves. In late September this condition of the foliage was very noticeable even from a distance, and was in strong contrast to the dark green color of the plants in the bordeaux plats. A similar condition had been observed in 1937 in the plats sprayed with similar copper fungicides. The chlorotic condition of the plants then was not attributed solely to the effect of the sprays, since the plats had been flooded and the yellowing of the leaves was assumed to be a response to that factor. Neither lime nor zinc sulphate added to the Basicop sprays decreased the injury, since the chlorosis was just as severe in the plants sprayed with these combinations as in those sprayed with Basicop and sticker only.

Reducing by half the amount of lime in bordeaux mixture did not cause any injury to the plants; those sprayed with a 8-6-100 mixture were just as dark green as those in the 8-12-100 plats. Some observers believed that the color of the plants sprayed with the 8-6-100 bordeaux was better than those protected with the standard mixture containing 12 pounds of lime. The differences were slight and if any existed they could not be detected with certainty from a casual examination of the plants.

Residual Copper on Leaves—Leaf samples for determination of residual copper were collected just before harvest from the dusted

Table 5. Residual copper on celery leaflets dusted or sprayed with various fungicides, 1938.

Treatment	Total Mg. Cu. in Sample	Mg. of Cu. Per cm2 of Leaflet Surface Area	Effectiveness in Blight Control. Rank:
Dusted Plats, Series No. 1, Wanders Farm, Comstock, Mich.			
Cuprocide No. 1	0.238	0.0043	1
20-30-50	0.204	0.0036	5
Basicop No. 2	0.199	0.0035	3
Bordow No. 1	0.103	0.0018	2
20-80	0.043	0.0008	4
Series 2, Wanders Farm			
Cuprocide No. 2	0.288	0.0068	2
Cuprocide No. 1	0.234	0.0056	1
Basicop No. 2	0.155	0.0037	5
Basicop No. 1	0.116	0.0028	6
Bordow No. 2	0.057	0.0013	4
Bordow No. 1	0.052	0.0012	3
Sprayed Plats, Dees and DeFeyter Farm, Decatur, Mich.			
Bordeaux 8-6-100	2.66	0.0169	2
Bordeaux 8-12-100	2.22	0.0141	1
Cuprocide 54	1.65	0.010	5
Basicop-sticker	1.55	0.0098	4
Basicop-lime-zinc	1.43	0.0091	8
Basicop-lime-sticker	1.26	0.0082	7
Basicop-lime-sulphur	1.24	0.0078	6
Copper-A-sticker	0.67	0.0043	3

plats on the Wanders farm and from the sprayed plats at Decatur. A leaf punch 0.6 cm in diameter was used for taking a single disk of tissue from 25 plants selected at random in each plat in the dusted series at Comstock. At Decatur a punch 1.0 cm in diameter was used and a single disk was taken from 50 plants in every plat. The disks were taken from bottom leaves of approximately the same age. The results of analyses of these samples for copper are given in Table 5.

In the two series of dusted plats on the Wanders farm Cuprocide dusts left heavier residues of copper on the leaflets than the other materials. The superior coverage achieved with these dusts may account for the heavier loads of residual copper on the plants. In each of the series of dusted plats Cuprocide dusts also gave the best control of leaf blights. There is little direct correlation, however, between the amounts of residual copper on the leaflets and comparative effectiveness of the other dusts in these series. Thus the 20-30-50 dust ranked fifth in effectiveness but second in residual copper on the leaflets. The chemical nature of the residual copper is apparently of more importance than the quantity.

The addition of stricking agents increased the adherence of the copper-sulphur-talc dusts, but a direct correlation between copper residue on leaves and effective control of leaf blights did not extend through the series. The Cuprocide dusts left much heavier residues of copper and they were the most efficient fungicides also, but a similar

correlation did not hold for the other dusts. Of the six dusts used, Bordow No. 1 for example, ranked third in effectiveness but sixth in the quantity of copper left on the leaflets. From these results it seems improbable that the inclusion of a sticking agent in the dust fungicides would greatly improve their effectiveness.

The superior sticking quality of bordeaux mixture has been noted in previous tests and was suggested as the basis for its top rank as a celery fungicide. The copper analyses seem to support this contention since the quantities of residual copper on the leaflets from plots sprayed with either 8-12-100 or 8-6-100 bordeaux were greatly in excess of those on the plants treated with other fungicides. As in the dusted plats, however, a similar correlation could not be traced through the series. Grasselli Copper A, for example ranked next to bordeaux in effectiveness and yet left the smallest residue of copper on the leaves. It is evident that factors other than adherence of the fungicide to the foliage are important in determining fungicidal efficiency. It is also apparent from these analyses that copper injury is not directly related to the quantity of copper in the residues. The bordeaux sprays left the heaviest deposits of copper and caused no perceptible injury while Grasselli Copper A, leaving the lightest copper residue, caused as much injury as other insoluble copper materials which adhered to the foliage in larger quantities.

Discussion

The favorable results obtained with the copper-sulphur-talc dusts in 1938 provide a basis for further experiments with combinations of these materials as substitutes for the copper sulphate-lime dusts. While the Cuprocide-sulphur-talc dust was the most satisfactory, it is probable that with further experimentation, other equally effective combinations may be prepared. With the Cuprocide dust consistently controlling leaf blights better than the copper sulphate-lime combinations in 1938, there is justification for extending the tests of this fungicide in 1939.

No substitute for bordeaux mixture has yet been developed that controls leaf diseases as well or causes less injury to the celery plant. With the exception of Copper A, the copper materials of low solubility used in the 1938 tests failed to control leaf blights satisfactorily and all of them caused perceptible injury. Hydrated lime or zinc sulphate failed to prevent injury to the foliage by basic copper sulphate. Unless additional tests reveal combinations superior to those used in the 1938 experiments, Michigan celery growers who use liquid fungicides should continue to rely on standard 8-12-100 bordeaux for protecting their crop against leaf diseases. The results with 8-6-100 bordeaux indicate that it may be safe to reduce the quantity of lime by one-half in the standard formula, but this cannot be recommended on the basis of one season's test. Experiments with bordeaux sprays containing even smaller quantities of lime will be carried on in conjunction with further tests of the 8-6-100 combination in 1939.

Summary

The results of dusting and spraying experiments for comparing the value of old and new materials for control of celery leaf blights are presented.

Cuprocide-sulphur-talc dusts gave superior control of leaf blights in 3 plantings of celery at Comstock. These dusts had smoother flowing properties and covered the foliage better than did any materials previously tested. Basicop-sulphur-talc and Bordow-sulphur-talc dusts were less satisfactory than Cuprocide, but about equal in effectiveness to copper sulphate-lime and copper sulphate-lime-talc combinations.

Bordeaux 8-12-100 and 8-6-100 controlled leaf diseases without perceptible injury to the foliage more effectively than the copper fungicides of low solubility, all of which caused sufficient injury to reduce yields. Grasselli Copper A was an effective fungicide but it caused injury to the foliage which was reflected in lower yields than those obtained from the bordeaux plats. Hydrated lime or zinc sulphate failed to prevent injury to the foliage by Basicop sprays.

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BULLETIN REVIEWS

Cir. Bul. 168—Production of Root Crops for Forage in Michigan— Churchill, B. R.—Root crops are valuable as succulent feed in the Upper Peninsula and the northern part of the Lower Peninsula. Rutabagas have done best in the cooler sections of the state while mangels have been most satisfactory in the corn-growing areas. Root crops should be grown on the same land only once in three or four years. They should preferably follow a sod crop and they respond with increased yields to applications of commercial fertilizer or barnyard manure. Based on trials at the Upper Peninsula Experiment Station at Chatham, recommendations are given for tillage practices, row widths, seeding rates, insect control, harvest and storage methods. (16 pp., 4 tables, 6 figs.)

Cir. Bul. 169—Marketing Michigan Vegetable Crops—Gaston, H. P.—Data are presented on the influence of varietal differences, sizes, grades and methods of packaging on sales and prices for common vegetable crops, such as cabbage, tomatoes, carrots, cantaloupes, beets. (22 pp., 7 figs.)

Spec. Bul. 297—Profitable Dairy Management—Wright, K. T. and Baltzer, A. C.—This study was based upon 499 dairy records obtained in 1932-36. The farms averaged 159 acres with 80 per cent of the acreage in feed crops. The average amount of livestock on the farms was 13 cows and accompanying young stock, 9 ewes, 118 hens, and slightly less than one sow. Average annual feed consumption per cow was approximately 1 ton of concentrates, 1.5 tons of hay, 2.7 tons of silage and other roughage and 166 days of pasture. Average annual labor required for feeding, milking and other care was 154 hours per cow. The average annual cost per cow was $140, including feed cost $57, labor $29, management $14, use of buildings and equipment $9, and other items $31. The cows averaged 339 pounds of butterfat a year. Income averaged $134 per cow. Thus the income from each cow lacked $6 of paying costs. Included in the costs is a labor and management charge of 28 cents an hour for labor on the cows. The income was, therefore, only 24 cents an hour for all time spent, or $37.08 labor and management return from each cow.

The farm cost of producing 100 pounds of milk was $1.79. Feed cost constituted 41 per cent of the total, feed prices being relatively lower than some other cost items during this time. Income from dairy products sold as milk, cream or butter, averaged $1.49 per hundred pounds of 4.3 per cent milk. Other credits increased that to $1.71, or 8 cents a hundred less than the farm costs of production.

The low-producing herds in this study, averaged 214 pounds of butterfat per cow, had a total yearly cost of about $107 a cow and paid a labor and management return of $16 a cow, or 11 cents an hour. High-producing herds, averaged 432 pounds of butterfat per cow, had a yearly cost of nearly $163 a cow, and paid a labor and management

return of about $52 a cow, or 31 cents an hour. The cost of producing butterfat was one-fourth, or 12 cents a pound, lower on the high-producing herds, even though twice as much management charge was included.

Many factors influenced the cost of producing a pound of butterfat, or a hundred pounds of milk. The low-cost one-fifth of the herds in this study produced a pound of butterfat at a cost of 32 cents, compared with 53 cents for the high-cost one-fifth. This would make a difference of about $70 in the annual return per cow in those herds which averaged 340 pounds of butterfat.

The lower butterfat costs on the more efficient herds, was about a fourth due to the 72 pounds higher butterfat production per cow, and three-fourths due to a $39 lower annual cost per cow. The factors responsible for the lower cost were: (1) more efficient feeding, (2) handling the herd with less labor, and (3) managing the herd so there was less depreciation per cow. (56 pp., 26 tables, 23 figs.)

Spec. Bul. 298—Interests of Rural People as Portrayed in Weekly Newspapers—Hoffer, C. R.—A classification and measurement of the content in a sample of 540 issues of weekly newspapers from 35 different communities in Michigan showed that local community news constituted 69.9 per cent of the total news space, general news 12.0 per cent, county news 9.9 per cent, and state news 8.2 per cent. When the local news was classified according to the percentage of space filled by different types of news, the following order was found: neighborhood news (which was mainly personal news items), personal, agriculture, school, church, civic and patriotic affairs, recreation, adult education, business, and health. The analysis of the editorials showed that a great number and variety of subjects were considered, though community development and cooperation received more emphasis than any other topic. (30 pp., 9 tables, 3 figs.)

Tech. Bul. 162—The Relative Importance of Various Factors Influencing Profits in Strawberry Production—Peacock, N. D.—A digest of the literature on strawberry production, together with a report on both field surveys and plot experiments to determine the relative importance of such factors as variety, source and size of plants, planting methods, soils, fertilizers, cultivation, mulching and renovation methods. Though all cultural practices and environmental conditions studied were found to influence plant growth and production and likewise production costs, returns and profits, the study as a whole emphasized the outstanding importance of a stand of plants in determining the success or failure of the enterprise. Beneficial effects of proper preparation of the plant bed, careful setting and early care of the plantation are evident as long as the plantation remains; conversely, no amount of subsequent attention will compensate for lack of those things before, at and immediately after planting. (75 pp., 31 tables.)

JOURNAL ARTICLE ABSTRACTS

Variations in the Number of Vertebrae of Swine.—Freeman, V. A.—Jour. Heredity. 30 (2): 61-64. 1939. [Journal Article No. 191 (n. s.) from the Michigan Agricultural Experiment Station.] A study was made of the variations in the number of thoracic and lumbar vertebrae in 182 pigs of the Michigan State College herd. Variation in number was found in all five breeds ranging from 19 to 23 so-called "body-vertebrae," with the extra number sometimes in the lumbar region and sometimes in the thoracic and associated with extra ribs. The difference in numbers of "body-vertebrae" found in males and females was not significant. The bacon-type Yorkshires had an average of .75 ± .081 more vertebrae than the Duroc Jerseys. Marked variations occurred within pigs of the same litter. Short ribs and small extra ribs were found.

Vertebrae counts were reported on 342 carcasses. Large numbers of "body-vertebrae" were associated with increased length of body. It was concluded that selection for length of body by usual methods has resulted in some increase in number of "body vertebrae".

The Use of Analysis of Co-Variance and Its Limitation in the Adjustment of Yields Based Upon Stand Irregularities.—Mahoney, C. H. and Baten, W. D.—Jour. Agr. Res. 58(5): 317-328. 1939. [Journal Article No. 326 (n. s.) from the Michigan Agricultural Experiment Station.] A method of correcting individual plot mean yields on the basis of stand suggested by Miles and Bryan was used in adjusting 108 individual randomized plots of sweet corn hybrids grown in 1937 where the "F" value before adjustment was highly significant for yield and stand respectively. The variances were reduced by adjustment but the efficiency of the method is evident in the reduction of the standard error of the experiment. Before adjustment there were three hybrids significantly higher, 5 significantly lower, and 18 non-significant as compared to open pollinated Golden Bantam. After adjustment there were two hybrids higher, 6 hybrids lower, and 18 neither significantly higher nor lower than Golden Bantam.

A much shorter and less laborious method for calculation of a new analysis of variance, suggested by Saunders, was likewise applied to the same corn data. It was found that if the adjusted plot means were carried out to two decimal places and the regression coefficient to four in the first method that the adjusted sum of squares derived by both methods would check approximately.

An example, using data from 1935 hybrid trials, is given to show that in the absence of correlation between yield and stand and with non-significant "F" values that nothing was gained by adjustment.

Another example is presented to show that, in the absence of a significant "F" value for treatment on tomato fertilizer tests and with an insignificant correlation between yield and stand, adjustment was efficient. Before adjustment three treatments approached the 5 per cent

point of significance, when compared to the check, and adjustment changed the means of the high yielding treatments and decreased the means of the low yielding treatments sufficiently to make these three means significant beyond the 5 per cent point.

Another example is presented where the treatment "F" is significant and the stand "F" approaches significance, but with one exception none of the means shows significant differences compared to the check. These data are taken from the 1937 fertilizer placement tests on Refugee beans grown for canning.

The Response of Quack Grass to Variations in Height of Cutting and Rates of Application of Nitrogen.—Johnson, A. A., and Dexter, S. T. Jour. Am. Soc. Agron. 31(1): 67-76. 1939. [Journal Article No. 338 (n. s.) from the Michigan Agricultural Experiment Station.]

Quack grass *(Agropyron repens)* was grown in sand cultures in the greenhouse with and without nitrogen. The cultures were cut weekly over a period of 24 weeks at heights ranging from the level of the sand to 8 inches above the sand. At the end of 24 weeks the high-nitrogen, close-cut cultures were dead while the low-nitrogen, close-cut cultures were still alive and had ⅓ of the original rhizome weight left. Cutting cultures high in nitrogen at the one-inch level was very injurious while the same treatment to low-nitrogen cultures caused only small injury. Minus-nitrogen quack grass plants stored organic reserves in subterranean parts at a more severe cutting level than did plus-nitrogen plants.

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Club Bulletins—

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H- 7 Corn Club Work.
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